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BIDS FOR SEWERAGE AND PAVING AT HAVANA, Cuba, will be opened on April 3. Bidders must deposit $500,000 with their bids and the successful bidder will be required to give $1,000,000 security, in cash or bonds, besides paying the Cuban government $250,000 on account of the extinguished rights of M. J. Dady. The work must be finshed in four years. The pumping stations must be maintained by the contractor for one year after completion and the other part of the sewerage system for five years. Mr. W. J. Borden, U. S. Engineers, is Chief Engineer of the city of Havana and Mr. Alexandro Rodriguez is mayor.

A METROPOLITAN WATER AND SEWERAGE BOARD for Boston and vicinity is proposed by a bill now before the Massachusetts legislature. The bill provides that the Metropolitan Water Board and Board of Metropolitan Sewerage Commissioners shall be abolished and their duties assumed by a new board of three members, to be appointed by the Governor and to be known as the Metropolitan Water and Sewerage Board. The chairman of the board would receive a salary of $5,000 a year and the other two members would receive $4,500 each. The bill has been passed to be engrossed in the house. As it has been endorsed by the committees of the legislature, it seems very probable that the bill will be enacted. In the course of the discussion an attempt was made to amend the bill so as to provide that one member of the new board should be appointed by the mayor of Boston, the second by a convention consisting of the mayors of cities and chairmen of selectmen of towns within the metropolitan district, and the third by the Governor, but this was defeated. The greater part of the heavy construction work of the metropolitan sewerage system has been completed, but a large part of the construction of the metropolitan water-works is yet to be done. The advisability of legislating either commission out of office while important work of construction remains unfinished is a question that has been raised and deserves careful thought. The bill, it may be added, is in accord with a suggestion made by the Governor in his address to the legislature. The Metropolitan Water Board consists of Hon. Henry H. Sprague, Chairman; Wilmot R. Evans and Dr. Henry P. Walcott; and the members of the Board of Metropolitan Sewerage Commissioners are Hon. James A. Bailey, Jr., Chairman; Tilly Haynes and George A. Kimball, M. Am. Soc. C. E.

THREE WATER POLLUTION BILLS ARE BEFORE the New Jersey legislature. One of them authorizes the present State Sewerage Commission to organize a sewerage district and build sewage disposal works whenever municipalities which it has notified to stop polluting the waters of the state have let half of the time limit pass without taking action. A second bill provides for the creation of sewerage districts and the appointment of commissioners to relieve the streams of the state from sewage pollution and prescribes how the work shall be done and the necessary money raised. Plans adopted by such district commissioners would be subject to approval by the State Sewerage Commission. The district commissioners would be appointed by the Governor and their compensation would be proportioned on the assessed valuations of the districts served, but could not exceed $3,000 apiece. The third bill, to make which feasible the second is proposed, incorporates the Lower Passaic Sewerage and Drainage District, comprising all those portions of Passaic, Bergen, Hudson and Essex counties which drain into the Passaic River below the Great Falls at Paterson.

BILLS FOR THE PROTECTION OF PUBLIC WATER supplies and for a state laboratory are to be introduced in the Wisconsin legislature. It is proposed to have plans for water supply and sewage disposal approved by the State Board of Health, and the contemplated laboratory would also be under the charge of that body.

A METER SYSTEM FOR THE WATER-WORKS of Norfolk, Va., has been recommended by Mr. W. T. Brooke, City Engineer, in a strong report to the city council. The alternative is an enlargement of the works, including another subsiding basin, mechanical filters, a pump, force mains and improvements to the distributing system. The city now uses and wastes about 112 gallons per capita per day, a large percentage of which Mr. Brooke believes is waste.

THE FRONTAGE WATER TAX AT ST. PAUL, MINN., has been declared unconstitutional. Such a tax has been levied for years past to meet the cost of new water mains. It appears that it has been arbitrary in amount, instead of in accordance with the benefit received. Mr. John Caulfield is secretary of the water board of St. Paul.

DAMAGES FOR FAILURE TO AFFORD FIRE PROtection have been awarded in a jury trial against the Greensboro Water Supply Co., of Greensboro, N. C. The sum granted was $25,000, the claim having been for $40,000 on account of the burning of the Benlow House in June, 1899.

A BILL FOR THE PREVENTION OF ELECTROLYSIS has been introduced in the legislature of Indiana. It provides that every street railway company in the state using the overhead trolley system or any other system employing an uninsulated, a grounded or rail return or feeding circuit shall install a double trolley system, or its equivalent, subject to the approval of the boards of public works, or of common councils in cities having no such boards. Failure to submit plans within 60 days of the date the act goes into effect, or failure to carry out the plans within six months of their approval, shall render any offending company liable to a penalty of $25 a day, and failure to pay such a penalty within 60 days of its declaration by a court shall forfeit the charter of the offender. The bill would also make unlawful, six months after it went into effect, the grounding or connection to the earth or any grounded construction wires conveying current for electric light, heat or power.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on Feb. 16 at Mill City, Nevada, on the Southern Pacific R. R. An express train ran into a washout. One of the sleeping cars was telescoped and four persons were killed.

ECONOMY IN LOCOMOTIVE FUEL CONSUMPTION is being investigated by a committee of the American Railway Master Mechanics' Association. A circular letter requesting opinions as to the most promising direction in which to effect a reduction in locomotive coal consumption have been sent out by the committee, whose chairman is Mr. A. E. Manchester, of West Milwaukee, Wis.

THE ELECTRIC RAILWAYS OF CANADA, according to late figures of the Dominion statistician, number 34, and aggregated, on Dec. 31, 1899, 630 miles of track. On this track 29,646,847 cars were run in the preceding year, and 104,033,659 passengers were carried. The amount of paid-up capital invested in electric railways was $21,700,000.

THE UGANDA RAILWAY BRIDGES were lately awarded to the American Bridge Company for the following reasons, as set forth in an official answer to the complaints of the British press: Nine English firms bid for the work, and the best bid in the nine was to place the bridges on shipboard in 60 weeks at £15 5s. or $76.25 per ton. The American bid was to have the bridges erected in 46 weeks, at £16 6s., or $81.40 per ton, delivered in any British port.

THE GENERAL OMNIBUS CO., OF PARIS, now controlling transportation within that city, was organized in 1855, to succeed about ten private and separate enterprises of this character. It commenced with 3,285 horses and 569 vehicles, and a capital of 16,000,000 francs, or $3,200,000. At the present time the company operates 45 separate lines of omnibuses; owns 12,368 horses, and the aggregate length of its routes is 162 miles. It also now operates a system of 19 tramways using horses, and 17 using some form of mechanical traction. These tramways aggregate 151.3 miles in length. The latter roads noted are operated by compressed air, by electric accumulators, and hot-air or steam motors, of the Rowan, Serpollet and Purrey types. The omnibus and tramway lines combined, in 1899, made 43,515,714 vehicle-kilometers; the omnibuses representing 25,477,000 of these. The company employs 10,845 people in its operating force, owns five power stations, with a total capacity of 10,000 I. HP., and has 58 depots for its service. The rolling stock includes 1,100 omnibuses and 482 tram-cars operated by horses, and 531 motors of all kinds. The gross receipts from 40,000,000 passengers, carried between March 1 and Dec. 31, were 8,608,563 francs, or $1,721,712.60. In 1899 the vehicles of the company carried 280,505,204 passengers, an increase of over 14,000,000, as compared with the preceding year.

THE GROWTH OF AMERICAN COMMERCE, in 1890-1900, is shown in a comparison made by the Treasury Bureau of Statistics. The following table shows the exports by grand divisions and countries and gives the value in round millions of dollars for the two calendar years 1890 and 1900:

Exports to	1890.	1900.
Europe	682	1,116
North America	95	198
South America	33	41
Asia	22	58
Oceanica	17	40
Africa	4½	23

THE UNITED STATES PIPE LINE CO., a rival to the lines of the Standard Oil Co., is reported as having started pumping oil from Bradford, Pa., to Marcus Hook, on the Delaware River, below Philadelphia. The length of the line is 380 miles, and 120,000 barrels of oil have been started on their way east. The plant includes four storage tanks, with a capacity of 30,000 barrels each, and a pier, 650 ft. long, extending out into the river at Marcus Hook. A fleet of ten modern oil-carriers is said to have been built for this service, and foreign dockage arrangements have been made. The new company has a capital of $10,000,000. The daily capacity of the line is set down at 20,000 barrels; and a refining plant is now in operation at Marcus Hook. The Standard Oil Co.'s pipe lines have an aggregate capacity of 100,000 barrels daily, and experts do not believe that the new line will have any influence upon values.

A 15-HP. PELTON WATER-WHEEL in the Kinkead Mill, Virginia City, Nev., has been running five years, using water under a pressure of 200 lbs. per sq. in. The shaft of the wheel has been renewed once, but the original buckets are still in use, and as the rim-speed of the wheel is about 4,500 ft. per minute, it is estimated that they have traveled oved two million miles.

A 7-MASTED SCHOONER is to be built this year by John P. Gordon, of Franklin, Me. The dimensions published are: Length on keel, 335 ft.; beam, 54 ft.; depth of hold, 32 ft.; draft in light trim, 18 ft.; about 4,000 tons net register. The estimated cost is $155,000.

THE BERTHIER ARCTIC EXPEDITION, according to the Montreal press, proposes to sail from Vancouver early next spring, Capt. G. E. Berthier will take with him 12 men, including scientists, sailors and hunters; he proposes to use an especially strongly built wooden ship and to enter the Arctic Ocean by Behring Straits—about July 1, and follow the north coast of Siberia to a point between 165° and 170° E. longitude, and then to head for the North. He expects his vessel to be frozen in for the first winter about 650 to 700 miles south of the Pole, and about 450 miles east of where the "Fram" was frozen in. While Capt. Berthier claims the endorsement of the Royal Geographical Society and expects financial assistance from the Canadian government, the item quoted does not note that he has the money necessary to buy or build the special ship in which he expects to sail "early next spring." As an inducement to the Canadian authorities he proposes to claim the Pole and the country between it and the north of Canada as belonging to the latter by right of discovery—provided he reaches the Pole.

THE FINANCES OF HAVANA are in a somewhat tangled condition, and a finance commission has been at work upon them for some time. According to their report—up to March 1, 1900, they found four general forms of outstanding municipal obligations as follows: A floating debt of $3,000,000 representing salaries, special services, supplies, materials, interest, etc.; a $5,000,000 bond issue of 1880, largely but not entirely cancelled by a later issue; a $7,000,000 mortgage of 1889, commonly called the Spanish Bank mortgage; a $3,000,000 mortgage of 1889, commonly called the Bank of Commerce mortgage. The report says that Havana needs about $25,000,000 to refund and properly regulate its somewhat complicated indebtedness. Havana would actually be able to sell 5% bonds for this amount at a premium were it not for a contract made in 1894 with certain parties to issue Havana bonds; these parties legally control the situation and so complicate it as to interefere with a radical change in financial management.

THE WATER-POWER PLANT AT MASSENA, N. Y.; ST. LAWRENCE POWER CO.

(With two-page plate.)

The largest water-power development in the United States, with the exception of that at Niagara Falls, is now approaching completion at Massena, N. Y. The plant now being installed will develop a total of 35,000 HP., but this capacity can be doubled and even quadrupled at small expense, aside from the cost of the machinery, whenever the demand for power shall warrant it.

Full descriptions of the work at Massena were given in Engineering News of Dec. 16, 1897, and Dec. 15, 1898, the first soon after work was first undertaken on the enterprise and the second after the work by the present contractor, the T. A. Gillespie Co., was well under way.

Without repeating the detailed information given in these preceding articles, it may be said that the general project, as shown in the accompanying map and profile, comprises a canal cut from the St. Lawrence River, at the head of the Long Sault Rapids, across a level plateau, to the valley of the Grasse River, where a sudden drop of about 40 ft. occurs. On the edge of this plateau the power-house is located, and the water discharged from it will pass down the Grasse River to its junction with the St. Lawrence, some 7 miles below the inlet of the power canal.

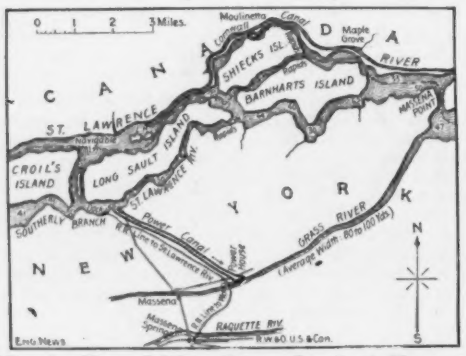


Fig. 1.—Map of Water-Power Canal, at Massena, N. Y.; St. Lawrence Power Co.
(From p. 396, Dec., 1897.)

The unusual topographical features which made this construction possible were first noticed by some of the local residents a few years ago. Levels were taken to secure more accurate information and a company was finally organized to undertake the work of developing the power. A contract for construction was originally let to the Lehigh Construction Co., of South Bethlehem, Pa., which let several subcontracts but did little actual work. After the failure of the concern in 1898, a new contract was made with the T. A. Gillespie Co., under which that company carries out the entire work of construction and is to turn the plant over to the Power Co. complete and ready for operation.

THE CANAL.

The largest outlay in the construction is for the excavation of the canal, 16,200 ft. in length, 262½ ft. in width at the water line and at one point 92 ft. in depth from the original natural surface to the canal bottom. For most of the distance, however, the depth of the canal bottom is only 35 to 40 ft. below the general level of the country. About 8,250,000 cu. yds. of earth excavation are required, or about one-fifth as much as for the Chicago drainage canal.

Not all this is being taken out in the original construction, however, as the full width of the canal, 262.5 ft. at the water line and 25 ft. depth ill provide a flow sufficient for 75,000 HP., whereas the present installation is on the basis of half this, or 35,000 HP. The canal is being excavated, therefore, to something over half its final bottom width, and the bench on the remaining part of the bottom can be taken out by dredges whenever the future demand for power shall make such enlargement necessary. This reduces the excavation on the present work to about 6,000,000 cu. yds.

The plateau through which the canal is cut is a glacial formation similar to that which borders the St. Lawrence throughout a large part of its course. No ledge rock has been encountered in all the three miles of excavation save at the power-house site, where a firm ledge of limestone furnishes an ideal foundation. The material on the line of the canal is chiefly clay, of all degrees of softness and with strata of boulders interspersed through it here and there, in a manner calculated to try the patience of a saint. The chief difficulty encountered, in fact, has been to keep the excavating machinery working efficiently. The variety of material encountered is such that a number of different systems of working had to be installed, and as the nature of the material may change entirely in the course of a few rods or even a few feet, machines often have to do more or less work on material to which they are not well adapted.

It may also be noted that while the contract was originally let to the Gillespie Co. at a price per cubic yard varied for different materials, it was found so difficult to classify and measure the different materials with the rapidly changing formation that both parties agreed to a revision of the contract upon a lump sum basis.

Had there been unlimited time available to carry out the work, the cheapest system of excavation, in Mr. Gillespie's opinion, would have been by dredging from the St. Lawrence end. It was necessary, however, to attack the work all along the line, and, therefore, both dredges and steam shovels have been used, according to the nature of the material, and the facilities for dumping the spoil. In the deep cuts, where the volume of the material to be removed made a long haul necessary to the waste-bank, steam shovels have been used. In the sags, where it was feasible to supply water to float dredges, dredging has been adopted; and the extensive use of the hydraulic system with water supplied by pumping is a unique feature of the work. The spoil banks formed by the waste-pipes were so located in each case as to drain their water back to the canal, so the same water is used over and over again. Both at the sag near the power-house and that between the two ridges large quantities have been removed by this system. A dredge at work on the last-named section is shown in Fig. 7.

A full description of the machinery employed on the canal at the outset was given in our issue of Dec. 15, 1898, above referred to. A visit to the work was made by a member of the staff of this journal on Oct. 27 last, and an inspection was made of the machinery then in operation.

Among the most effective machines noted were the steam shovels working in connection with traveling inclines near the power-house end of the canal and shown in Figs. 3 and 4. Upon these inclines traveled a pair of automatic dumping cars, which alternately received the discharge from the shovels, hoisted it to the top of the incline and dumped it over the end. The clay was kept from sticking to the cars by playing a hose on them as they were filling. Farther north, in the deep Andrews Ridge cut, shown in Fig. 5, steam shovels were at work loading into dump cars, which were hauled out of the pit by small locomotives. As this work was on the lowest level, the grade out of the pit was more than the locomotive could climb with the loaded cars. To help it up the grade, a hoisting engine was set at the head of the incline and a wire rope was carried from the drum down the slope and hooked onto the train when it was ready to start. The locomotive and hoisting engine together hauled the train out of the pit, and the rope was then detached and the locomotive alone hauled the train to the dump.

On the St. Lawrence end of the canal, the excavation has been completed to the final level and such a width that boats can go from the St. Lawrence nearly a mile along the canal, and dredges are at work here dumping into scows which are towed out and dumped in the same water at the head of the rapids. The only subcontract let by the Gillespie Co. on the canal work was to Daly & Hannan, of Ogdensburg, N. Y., for the deepening of the canal by dredging to its final level. To carry out this work the above-named firm built a huge dipper dredge, with a scoop of 6 cu. yds, capacity. The hull of the dredge was built by Daly & Hannan, Ogdensburg, N. Y., and the machinery was built by the Bucyrus Co., of Milwaukee. It was intended to have this dredge at work early in the season of 1900; but delays in its completion occurred, so that it was not brought on the work until November last. Fig. 6 is from a photograph taken near the St. Lawrence end of the canal on Aug. 1, 1900, and shows the nearly completed channel, with the longitudinal ridges left by the smaller dredges. The final clean-up of this section has since been made by the large dredge above referred to.

In its course of three miles the canal intersects highways, which have to be restored, and to effect this without interfering with the passage of steamers through the canal, high-level single-span bridges have been located at the summit of the Andrews' Ridge and Alden's Ridge cuttings (see profile). These bridges will have a single span of 408 ft. and curved top chords. They will be built by the Hilton works of the American Bridge Co., which also has the contract for the structural steel work at the power-house.

The finished canal for 35,000 HP. will have a depth below the mean water-level with closed head gates varying from 18 ft. at the St. Lawrence end to 20 ft. at the entrance to the basin next the forebay. This basin will have a depth of about 25 ft. The velocity of the current in the canal with all the turbines in operation will be about 3½ miles per hour, and the loss of head in the three miles is estimated at about 3 ft.

THE DAM AND POWER-HOUSE.

The dam and power-house at the Grasse River terminus of the canal is a monolithic concrete structure, and one of the largest and most elaborate that has ever been undertaken in this country. A dam is commonly thought of as a structure thrown across a valley to hold back the water of a stream; and this structure, erected on the edge of a steep bluff, would hardly be recognized as a dam at first. When the canal is completed, however, and the water stands against the heavy wall of masonry, its function as a dam sustaining the pressure of the water behind it will be clearly recognized.

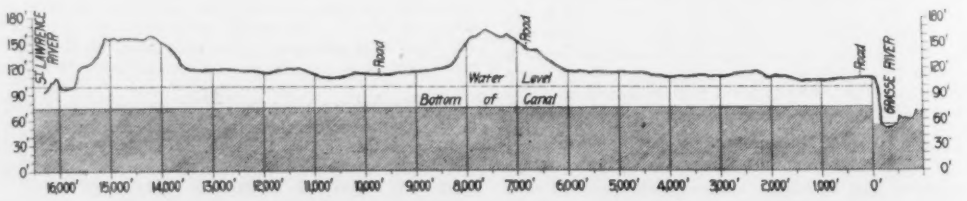


FIG. 2.—PROFILE OF MASSENA CANAL.

As already stated, the dam and power-house are founded on the firm limestone which forms the bed of the Grasse River, and it was only necessary to clear off the overlying sand and clay and smooth its surface to obtain an ideal foundation for the concrete superstructure. At the side of the power-house, the Grasse River was diverted from its course for a short distance and considerable rock was excavated to give a free exit to the tail-race water. Selected portions of this rock were saved and crushed as required for use in making concrete.

The concrete plant consisted of a pair of Gates rock breakers, with screens and elevators, delivering the broken rock to overhead bins, whence

it descended by gravity to the mixing platforms. Two cube mixers were used, the materials for the mix being measured in hoppers on a platform above. The cement was delivered in bags. The mixed concrete was discharged into narrow gage hopper cars, which were drawn by a small locomotive to the place of use.

Returning to the design of the dam and power-house, it will be clearly understood by a study of

FIG. 3.—STEAM SHOVEL AND INCLINE.

the cross-section and plan, Figs. 8 and 9. The dam is a heavy wall, 8 ft. thick at the water level and 15 ft. thick at the floor of the turbine-chambers. These chambers are located on the back of the dam and are separated from each other by 6-ft. thick walls at right angles to the main dam. The chambers between these walls are each 32 ft. in width and can be separated from the forebay by closing three pairs of swinging gates, similar in construction to canal lock gates. These gates are only closed, of course, when it is desired to get at the turbines in the chamber.

As seen by the cross-section, there are three double-horizontal turbines in each chamber, all mounted on a common shaft. Each double turbine discharges through a 10.6′ draft-tube, built into the concrete floor of the chamber, and extending below low-water mark in the tail-race chamber below. A circular opening through the dam is located at the center of each chamber, and is closed by a steel bulkhead. Through a stuffing-box in the center of this passes the shaft to which the turbines are attached, and this is coupled directly to the shaft on which is mounted a 5,000-HP. generator in the dynamo room. The governor shaft, controlling the turbine gates, also passes through a stuffing box in this bulkhead.

Each single turbine has a nominal capacity of 1,000 HP. when working under the minimum net head of 32 ft., and at a speed of 150 revolutions The turbines were built by the Stillwell-Bierce & Smith-Vaile Co., of Dayton, O.

It will be readily understood that the computation of the stresses which will be set up by the water-pressure in the dam and its supporting arches, and in the floor arches and walls of the turbine chambers, was a task of no small intricacy. A point of especial importance was the possible temperature strains in the long concrete dam, which in the present construction is no less than 350 ft. from end to end, and will be double this length when the capacity is increased to 75,000 HP. To provide against this contingency, steel rails were embedded in the dam in its construction, and the joints between successive sets of rails was made to come opposite the center of the transverse walls which separate the turbine chambers. It is expected in this way that if the contraction due to excessive cold weather should cause cracks through the dam, these will occur opposite the walls, and not at the part of the dam opposite the turbine chamber, where a through crack would allow water to pass through. It may be pointed out, however, that even should these precautions fail, and cracks occur in the main dam, the facility with which any part of it can be laid dry and a leak calked, makes such an occurrence of no great moment.

As seen in the cross-section, the turbine chambers to the right of the dam are covered with a flooring, which carries a sidewalk, a street and steam and electric railway tracks, the whole constituting in fact a bridge over the canal and replacing the roadway which was formerly located at this point. A crane track is also provided in each turbine chamber upon which a traveling crane can be run to handle the turbine parts when necessary.

In front of the gates of the turbine chamber a substantial steel trestle extends across the forebay, and upon its front are carried the racks of screen-bars. As every hydraulic engineer knows, the question of keeping the channels of a hydraulic power plant clear of ice is one of great importance in far northern latitudes; and the troubles experienced from "frazil," or anchor ice, in power plants with intakes in rapid water on the St. Lawrence are well known. The Massena plant is favorably situated, however, in that the water is taken from the St. Lawrence above instead of below the rapids, and flows for three miles through the canal at low velocity before entering the screens. Very early in the winter a sheet of ice may be expected to form on the canal, and after that occurs no trouble with anchor ice will be likely. To provide for possible icing-up of the screen bars before the canal closes, and in fact for stoppage of the screen by any cause, the construction, shown in Fig. 12, has been adopted. It will be seen that the two upper panels of screen bars instead of being secured to the trestle which supports them, are simply hung from the top and rest against it. Now the chief use of the screen bars is first to catch floating matter, and second, to catch stones, water-logged pieces of wood, or other obstructions rolled along on the bottom by the current. Thus the important functions of the screens are really discharged by the top and bottom panels. The middle panels very seldom catch anything except frazil. It is proposed, therefore, in case the screens become iced up, to simply raise the movable screens one section upward, and leave the central opening clear. Floating trash or any rolled on the bottom will still be caught and the water can pass freely through the central opening regardless of anchor ice.

Turning now to the tail-race side of the building, Fig. 13, shows the openings of the tail-race tunnels. It will be seen that stop-plank grooves are left in front of each opening, and by closing these and pumping out the water, the interior of any tail-race chamber can be laid dry for examination or repairs.

Over the tail-race arches is the dynamo room, the dam forming one of its sides. The other side has an extension overlooking the Grasse River, and a gallery on the same level about 15 ft. above the main floor. These run the whole length of the building.

The photograph from which Fig. 13 is repro-

FIG. 4.—PARTIALLY-EXCAVATED CANAL, WITH SHOVELS AND INCLINES AT WORK.

duced was taken in November last, and shows the steel frame in place for the covering to the dynamo room. The plate girder seen carries one side of an 85-ton bridge crane, which spans the generator room, the other end running on a track laid on the dam. The walls of the power-house are laid up in brick, plastered with cement both inside and outside to make it harmonize in appearance

with the concrete work below. The architectural appearance of the building has had careful attention, the extension on the Grasse River side affording an opportunity for good effects.

ELECTRICAL EQUIPMENT.

As already stated, the generators are each of 5,000 HP. nominal capacity. The total weight of each is about 215 tons. They are alternating current, rotating field machines, developing a current of 5,000 HP. at a potential of 2,200 volts. Separate direct-current exciters are used to charge the fields, and of these three are provided, each with its independent turbine, headgate chamber and tail-race chamber. Any one of these can furnish sufficient current to charge the fields of the entire plant, and the three are provided to guard against the remotest possibility of breakdown from lack of exciting current.

From each dynamo the current is carried by copper feeders to the main switchboard; and here a notable innovation is introduced. Instead of the huge marble wall with switches and other instruments scattered over it which has becaome the familiar appendage in electric power stations, there will be instead a central operator's desk, or controlling stand, somewhat as shown (from a rather crude sketch) in Fig. 14. On this stand are placed electric controlling keys mounted on a number of marble slabs or tablets, one for each generator. These keys are arranged on the interlocking system, and they will operate, by means of local battery circuits, a series of compressed air valves and pistons. The latter will, in turn, control a series of switching stands, one for each generator, equipped with the necessary cut-outs and switches. These stands will be located upon the extension and raised gallery, each approximately opposite its corresponding generator. Each stand will carry three-pole carbon shunt circuit-breakers, in series with which will be three-pole double-throw switches. The circuit-breakers and switches are controlled by means of compressed air, as previously stated, from the central controlling stand operated by the engineer. Stands, similar to the switching stands, are provided for the different outgoing circuits. The illustration shows the central controlling stand; in front of the operator, and raised high enough above him to afford a clear view of the floor of the entire station, are seen groups of indicating instruments, in the circuits of the various generators. The operator thus has under his eye at every moment the huge generators themselves, their corresponding switches and indicating instruments, and in reach of his fingers are the electric buttons, by means of which the entire plant is regulated and controlled.

This arrangement affords a positive system of control, from a central view point. The controlling apparatus is operated pneumatically, by which means manual labor is entirely dispensed with, and this greatly increases the precision and speed with which the electric output may be regulated. It affords a complete isolation of the different generators and their switches, thus greatly diminishing the chances of accident; it removes the operator entirely from contact with the electric conductors themselves, thus obviating all risk of personal injury. Behind the operator, and occupying positions corresponding to the switching stands, will be located a series of pneumatically-controlled rheostats for regulating the magnetic fields of the different generators.

It is worthy of note that this is a greater advance in the control of vast power by a single man's hand than has ever been made before. The operator at this desk has under his absolute control, to be altered by the pressure of a finger, a power which in the completed plant will be double that of the greatest ocean steamship.

The contractors for the entire electrical equipment are the Westinghouse Electric & Manufacturing Co.

FIG. 5.—DEEP CUTTING THROUGH ANDREWS' RIDGE.

UTILIZING THE POWER.

Massena is, as we remarked a year or two ago, a long way from anywhere. There can be only a trifling market for the plant we have described in supplying current for electric lighting or electric railway purposes. The managers of the enterprise, therefore, are looking to the establishment of such industries as pulp and paper manufacture or some of the lines of chemical industry which now make such large use of electrical power to furnish a market for the power which they have developed. The unique natural advantages of their site have enabled them to develop this power at a total expense so moderate that it can be furnished to manufacturers at a very low figure and still leave a profit for the company.

A notable advantage of the site is its location on the St. Lawrence water route. In fact, the newly-built canal will furnish a route on United States territory past the Long Sault Rapids, in place of the Cornwall canal in Canada. The Power Company's canal is deep enough for any vessel navigating the St. Lawrence, and with the addition of a lock near the power-house, and a little dredging in the Grasse River, a new and better route will be open to vessels navigating the St. Lawrence. Surveys for the above-mentioned improvement were made the past summer by Mr. John C. Churchill, U. S. Asst. Engineer, in accordance with a provision in the last River and Harbor bill.

This water transportation not only gives cheap carriage to all ports on the Lakes, but gives access to the stores of pulp wood and other raw materials which are reached by the Canadian waterways. The managers, therefore, look forward with confidence to the development of a manufacturing city around their plant to make use of the cheap power which they have produced.

The names of the contractors for the various parts of the work have already been mentioned. The engineers of the work are Mr. John Bogart, M. Am. Soc. C. E., of New York, and Messrs. Kincaid, Waller & Manville, of London, with Mr. John R. Freeman, M. Am. Soc. C. E., of Providence, R. I., as Consulting Engineer. Mr. Wm. H. Cushman is the Resident Engineer at Massena.

The offices of the St. Lawrence Power Co. are at 40 Wall St., New York city, where its active officers are Mr. Wm. F. Zimmerman, M. Am. Soc. M. E., Vice-President and General Manager; Mr. Warren A. Ransom, 2d Vice-President; C. R. Hebard, Secretary and Treasurer.

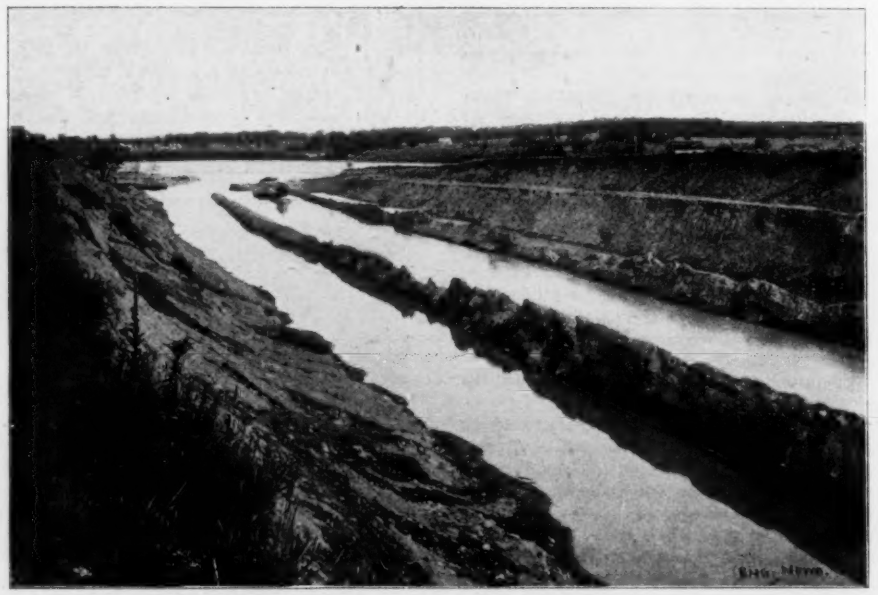


FIG. 6.—JUNCTION OF CANAL AND ST. LAWRENCE; ALDEN'S RIDGE CUTTING.

STADIA SURVEYS FOR RAILWAY LOCATION.

By H. P. Boardman.*

Many engineers, especially among the younger men of the profession, fully realize, or at least think they realize, the utility of the stadia method of surveys as applied to railway location. The present article is not intended so much for those who have actually used stadia measurements in railway location, as for the inexperienced, for the former should need no arguments to convince them of its advantages.

The writer has worked in several different capacities on railway preliminary and location work with fully equipped two-instrument parties of the old style, consisting of from 9 to 11 men, according to the amount of clearing required. He has also used contour maps for other than railway work and has worked on topographic surveys made by the stadia method. He has long been convinced that much of the work done by the old style railway parties could have been avoided,

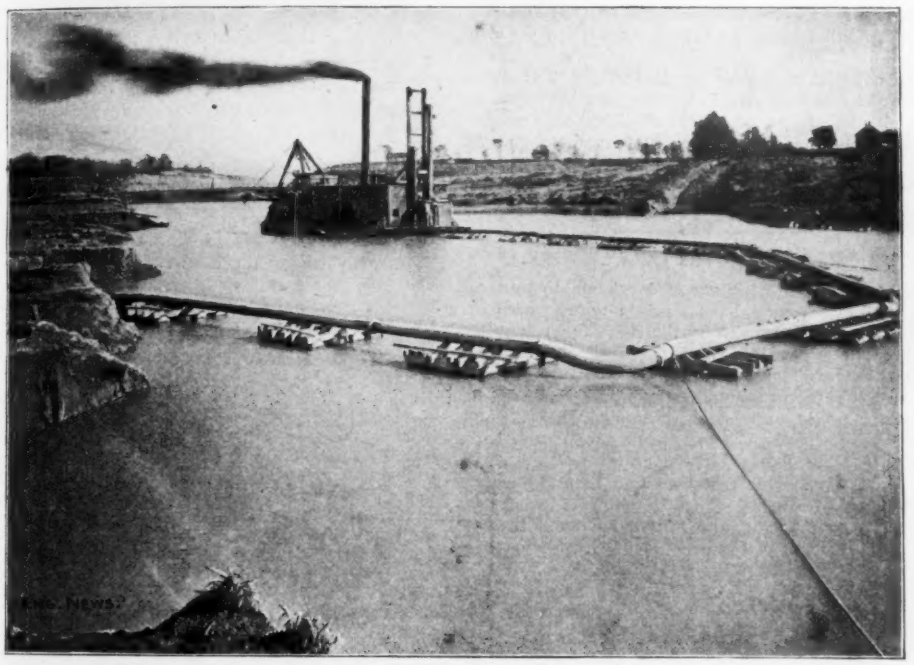


FIG. 7.—HYDRAULIC DREDGE AT WORK.

time and money saved in surveys and certainly in some cases a better location secured, giving a more economical line, had a judicious use been made of stadia measurements.

Just think of the lumber thrown away in stakes and the trouble it causes the protesting farmer to pull them up; of the energy and timber wasted in cutting down trees and the grain destroyed by a squad of ten men breaking a path through a field of 8-ft. corn, especially when this process is repeated half a dozen times before a satisfactory line is found.

By the stadia method no stakes are wanted (except for transit points) until final location; very little clearing need be done, as transit points can be so selected as to offer a minimum of obstructions to the sight, and side shots can usually be picked exposing all of the stadia board that is necessary for an observation without any clearing. Of course where underbrush is thick, clearing will be required for practically every observation, but the same is true of a transit, tape and level survey. In the case of cornfields or similar obstacles, a transit point can often be located on a high point in or at the border of the field affording an extended view of the whole or a large portion of it.

Many engineers who have never used a stadia transit seem unable to comprehend the degree of accuracy that can be easily attained in measuring distances and differences of elevation by this method. With a good transit, no more than ordinarily careful work is required to keep within the limits of error of 0.3 ft. per mile in elevation and 5 ft. per mile in distance, and if the error is more than double this amount, the notes should be searched for evidence of some mistake in observation. It will be seen that it is practicable to easily do work as accurately as there is ever any need of on a preliminary survey. As to the liability of large errors creeping into the work, the vertical angle and distance should always be read twice between any two adjacent transit points, namely, once on foresight and once on backsight, and the two averaged if they check closely. If they fail to check, the mistake can be located at once. This gives a good check against any mistake in observation or recording which would affect the work to follow.

The reduction of notes is a simple matter by the use of a stadia reduction diagram, such as the one described in the "Journal of the Western Society of Engineers" for December, 1898, which is one of the best in existence. All the notes taken in a day can be reduced in the evening, and the elevations and distances for all transit points, at least, should without fail be worked up to date every night.

As to the scope of stadia work and the make-up of the parties the writer would make the following suggestions.

For a reconnoissance survey, if it is in a settled country and maps are obtainable on a scale of anywhere from ½-mile to 2 miles to the inch, correctly showing all public highways, streams and towns, the reconnoissance may be made on horseback, in carriage, on bicycle or on foot, using an aneroid barometer and a Locke level, and marking the routes traversed on the map, making notes of topography and other matters pertaining to railway location.

If such maps are not to be had and the topography, the distribution of timber, etc., are such as to make it difficult to describe and retrace a route without any sort of an instrumental survey, then the stadia may become useful. The party for this kind of reconnoissance work need consist of only two men ordinarily, and no time should be wasted in details or refinements. The general route to be examined between certain points having been decided on, a good plan would be to run a zigzag meander line covering a belt sufficiently wide to be sure and include the desired line. Or it may be better in some cases to run several lines, each of which covers a comparatively narrow territory, but which together cover a sufficiently wide territory to include all lines worth considering. The locating engineer should lead the way with the stadia board, selecting the transit points and giving few intermediate readings, only sufficient to give elevations of a few controlling points, such as water courses and hills. Azimuths can be carried along by compass bearings, but where convenient it would be better for the transit man or observer to put up a rough backsight when he leaves a hub to move up. He should use the needle for a check and it will aid in finding an obscure backsight, but it is hardly worth while to have a back flagman with stadia board for this rough work. The vertical angle can be roughly checked from the backsight, but since there is no check on the distance from the backsight, care must be used to avoid large errors in the foresight. Long sights between hubs are permissible in this work, from 1,000 ft. to 2,000 ft., reading the distance by half stadia interval when necessary.

The observer will have time to spare in this work, and he should make sketches in his notebook showing the direction and lengths of the courses approximately, to a convenient scale, and filling in with topography by sketching contours. With practice one can soon learn to represent topography for considerable distances by this method where the view is not obstructed. In a country where land lines are plainly in evidence, it may be well to make these sketches in sections, either one or four per double page in notebook, and take occasional readings on section lines for a check.

The locating engineer should make notes especially as to the nature and size of streams, outcrops of rock, etc., and make suggestions as to where he thinks the next more detailed survey should run. He should assign consecutive numbers to the transit points, always entering the last one in his notebook to check the observer's notes and should refer to intermediate shots as A, B, C, etc.

This kind of a reconnoissance is more elaborate and expensive than an aneroid survey, and is slower, but it gives much more information and in some cases is justified. In fact, it may be made to give more comprehensive information for deciding a final location than several of the old style preliminary lines. The notes of such a survey should be worked up in the shape of a rough contour map which will show drainage lines and principal elevations and depressions correctly along the meander line and approximately elsewhere. Upon this map can be laid out one or more lines to be examined more in detail.

The general course of the location having been decided on by this means, or by the aneroid survey, it remains to make more detail surveys developing the topography sufficiently close to enable the most economical line to be located.

For this purpose a more complete party is required. The locating engineer should spend most of his time in the field with the party. The observer should not be burdened with a notebook, but should have only his transit to attend to. He should be accompanied at all times by the recorder, who should record all readings called off by the observer, repeating them for a check. A back flagman carrying a stadia board should be kept at the last hub passed, for a permanent backsight. In open country three stadia board men may be used, one to give sufficient center line shots to develop an accurate profile and one of the others for each side of this line. If necessary to equalize the number of shots per man, the center-line man can cover a narrow belt each side of the center line and he should in a measure direct the location of the side shots so that enough will be taken to fairly represent the topography and yet not more than are necessary.

When the locating engineer is with the party he can lead the way and select the advance transit point, planting for a foresight a flag pole with paper or other material so attached as to readily catch the eye. After this he can occupy the time by making notes of his environment.

When the locating engineer is absent, working up notes or otherwise engaged, the center-line stadia board man can first go ahead, locate the next hub, plant a foresight and then double back on the line, giving profile and side shots. In this manner a belt averaging from ⅓ to ½-mile in width can be covered in ordinary open country. In some places it will be unnecessary to cover that width and in others it will be desirable to cover

*Assistant Engineer, Chicago & Alton Ry.

more, sometimes necessitating branch lines. Where the center line or meander line of such a survey is sure to be pretty near the located line, the belt to be covered need not be very wide, but ordinarily it will be well to take about all within easy range, as that will give more latitude for laying out experimental lines on the contour map.

Under ordinary conditions of atmosphere the distances between transit points or stadia stations should not exceed 1,200 ft., and better results will generally follow if the average is from 800 to 1,000 ft. Always read horizontal angles by azimuths; that is, South = 0° and 360°, West = 90°, North = 180° and East = 270°, so that whenever the plate is turned with vernier "A" at 0° the telescope will point south.

The close attention of the observer will always be necessary to avoid little mistakes, such as setting top or bottom wire instead of center wire, reading the vertical angle plus when it should be minus or vice versa, etc. When the difference in elevation is slight, either plus or minus, it is a good plan to take a "level reading" in addition to the vertical angle reading. The observer should carry with him a measuring stick about 5 ft. long, graduated at the upper end to correspond to the stadia board, with which to measure the "H. I.," or height of instrument above the hub. It is a good plan to have the even foot or half foot mark just below the average H. I. made prominent on all the stadia boards, so that the observer can always readily pick his H. I. point on which to set the center wire for the vertical angle reading.

A convenient order of procedure for the observer is as follows: First measure and call off the H. I., which should always be recorded; then, sighting at the stadia board to be observed, clamp the vertical circle with bottom cross hair at some even foot mark and the center wire near the H. I.; call off the distance or stadia interval and without removing the eye from the telescope turn the center horizontal wire to the H. I. and the center vertical wire to the stadia board, clamping both; read and call off the azimuth and the vertical angle.

When several stadia board men are used a code of signals will have to be devised to avoid confusion. In timber or underbrush, where some clearing is necessary, it may be well for each of the stadia board men to carry a hatchet or hand axe. The above suggestions as to make up of party, etc., are only general, and may be departed from to a considerable degree in particular cases and still permit of the economical use of the stadia method of survey.

The notes of the stadia survey should be sent to the office for plotting as fast as the notebooks are filled, and a contour map worked up on tracing cloth so as to be readily reproduced. A number of blue prints (or white prints are better) should be made to be used for laying out experimental lines. Estimates of the cost of these different experimental lines can be made for comparison, their profiles being worked up by distances scaled and elevations interpolated from the contour map. On sidehill work the contour map will enable the cross sections to be closely approximated. The experimental lines should be worked up and compared under the direction of the locating engineer, whose intimate knowledge of field conditions, coupled with the advantage of having the complete topography before him as in a bird's-eye view, should result in securing the best line obtainable.

Without belittling the work of the locating engineers who have depended on their "eye for country," and many of whom have made excellent locations, the writer thinks the above method more scientific and generally more sure of giving an economical location in the proper use of the word, not necessarily meaning the cheapest in first cost.

Mr. Wellington advocated the use of stadia surveys and in summing up the pros and cons, one of the greatest objections he could see to the use of this method was the tendency toward a purely office location, neglecting many important points which can only be properly sized up in the field. It seems to the writer that if a locating engineer of good judgment directs both the surveys and the paper location, as suggested above, this objection would be largely overcome.

If a cheaper and less accurate preliminary survey is desired, the stadia party may consist of only four or five men and instead of taking many side shots the adjacent topography can be approximately shown by contour sketches, enabling more ground to be covered in a day. By this method, followed by the contour map location, a better line should be obtained and for less money than is ordinarily possible by a two-instrument preliminary survey. In some localities it would be advisable to take borings to determine the amount of rock to be encountered on the different experimental lines and these borings could be located from the nearest stadia stations.

The location having been finally decided on, it remains to stake it out on the ground. In this operation stakes should be set every 100 ft. as usual and Y levels run over the line. Tangents can be run out to intersections and the P. C. and P. T. at once located, the degree of curve having been fixed, and the curve run in so that stakes can be set in their final position. Or, better yet, where spirals or transition curves are to be used, they may be at once staked out so that the stationing will require no future corrections on that account.

In conclusion the writer is inclined to believe that very few cases of railway location arise in which money cannot be saved either in the surveys or in the construction and operation, or in all these, by a judicious use of the one-instrument stadia method of surveys, coupled with paper location on contour maps.

A WHEELBARROW FOR RAILWAY WORK.

Wheelbarrows with grooved wheels to run on the rail head have been used in many cases on railway section work, particularly for removing the earth excavated from ditches, etc. The "trackbarrow," shown in the accompanying cut, is on the same principle, but the axle is placed at a slight angle to the center line of the barrow, so that the man need not walk astride the rail, as with an ordinary wheelbarrow, but can walk at either side, which enables him to make much more rapid progress. The cut shows the barrow in place on the rail, and it will be noted that it

The "Trackbarrow" for Railway Maintenance Work.
Edward B. Peirce, Inventor.

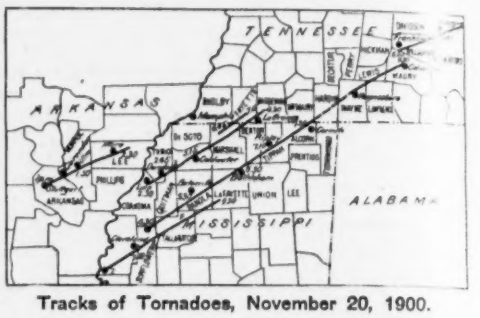
is set at a slight angle to the rail, the outer leg being close to the rail. It may be run on or off the track, and the wheel can be fitted to existing barrows. Special appliances may also be fitted to enable the barrow to run on or off the rail without lifting it. This "trackbarrow" is designed to supersede the section gang's push-car for handling dirt on railway maintenance work, such as ditching, etc., and also for handling small quantities of ballast. Its cost is from $3 to $5. It has been patented, and is being introduced by Mr. Edward B. Peirce, 17 Belmont St., Lowell, Mass.

TORNADOES IN TENNESSEE, MISSISSIPPI AND ARKANSAS ON NOV. 20, 1900.*

By S. C. Emery, U. S. Weather Bureau.

During the afternoon and evening of Nov. 20, 1900, the section of country embracing southeastern Arkansas, northern Mississippi and western Tennessee was visited by at least six distinct tornadoes, all of which were destructive and exhibited the usual characteristics of such storms. All moved in exactly the same direction [illegible] parallel lines, with a rate of progressive motion of [illegible] 45 to 60 miles an hour, as shown in the accompanying [illegible] map.

Some portions of the country through which the [illegible] does moved are thickly settled, and as everything [illegible] the limits of their narrow paths was destroyed, the [illegible] of life and property was very severe. The actual [illegible] resulting from these storms number at least 73, [illegible] large number of persons were seriously injured [illegible] much greater number rendered homeless by the d[illegible] tion of their dwellings. Unpicked cotton was s[illegible] from the stalk and scattered broadcast over the co[illegible] and instances were noted where large quantities o[illegible] ton were carried by the tornado to distant fores[illegible]



Tracks of Tornadoes, November 20, 1900.

deposited upon trees, making them appear to be covered with snow.

In some places the cloud appeared as a great ball of fire, and at others small balls of fire shot out of the lower portion of the cloud. The most notable feature, and the one mentioned by all who observed the storms, was the intense and constant lightning, the extreme brilliancy of which in some cases turned night into day. The noise attending the passage of the storm cloud is generally described as a deep roar like the moving of many railway trains, which could be heard for some time before the storm arrived. The warning thus given enabled many to seek places of greater safety and was the means of saving life.

The first tornado reported originated in eastern Arkansas, and passed about 5 miles south of the town of Stuttgart, in Arkansas county, at 1 p. m. Upon reaching a high ridge bordering the St. Francis Basin on the west, known as Crowleys Ridge, the tornado left the earth and was seen no more. The town of Moro, in Lee county, was almost entirely swept away, only 4 buildings left standing. Total number killed in Arkansas, 6. The tornado traveled 45 miles in 1 hour and 15 minutes.

Tornado No. 2 started in the vicinity of Moon Lake, in Coahoma county, Miss., and passed near the town of Lulu, Miss., about 2.30 p. m., and through Dundee, Miss., at 2.45 p. m.

The destructive character of this storm was first felt near Dundee, on the farm of Mr. F. M. Norfleet. On this farm 6 persons were killed and many buildings destroyed. From Dundee to Arkabulta, Miss., the storm track was marked by wrecked buildings, fallen trees and general desolation; 8 white persons and 1 negro were killed. Arkadelphia, Miss., is a town of about 1,000 inhabitants and scarcely one of them escaped injury. Hundreds of homes were swept away without warning, and 11 persons were killed and a very large number severely injured. Continuing its northeasterly course the tornado reached Strayborn, Miss., at about 3 p. m., killing 11 people.

The next important town visited by this tornado was Lagrange, Tenn., where it arrived at 4.30 p. m. and destroyed about 20 buildings and caused the death of 2 persons. The property loss at this place aggregates $50,000. Within a path 175 yards wide practically every building was leveled to the ground. After leaving Lagrange the tornado traveled but a short distance and then disappeared. Total distance traveled by the tornado from Dundee to Lagrange, 80 miles; time 1 hour and 50 minutes, an average rate of movement of about 60 miles an hour.

A strange relic left by the storm at Lagrange was a tin sign bearing the inscription "Johnson Bros., Lula, Miss.," evidently brought by the tornado from that place more than 80 miles distant. From a frame house on Main St. was extracted a small piece of rotten wood which was driven half through a heavy oak plank, despite the fact that the flying splinter was so decayed that it crumbled while being drawn out. The Methodist Church was destroyed in an even more singular manner. Each of the four walls fell inward, forming a succession of layers, one on top of the other, and all surmounted by the steeple. The cyclone wind, after the roof had been taken away, evidently formed a vacuum inside the church, which resulted in all the walls closing in.

Tornado No. 3 started about 25 miles south of No. 2 in the northern portion of Sunflower county, Miss., passing 6 miles south of the town of Sumner, Tallahatchie county, at about 4.30 p. m. In its movement northeastward from Sunflower county, the storm passed near Batesville at 5.30 p. m., doing only slight damage. From there it seems to have touched the earth only occasionally, passing over Abbeville, and striking the earth again near the town of

*Condensed from a paper in the "Monthly Weather Review."

Bethlehem, in Marshall county, at 6.30 p. m., where it destroyed 3 buildings. At Corinth, Alcorn county, it arrived at 7.30 p. m., but as it passed to the south of the town no fatalities occurred. The distance from the point of starting to Corinth is about 125 miles; time, 3 hours and 30 minutes.

After entering Tenessee the storm continued its course to the northeast, and reached Columbia at 9.30 p. m. The tornado passed through the suburbs of Columbia, sweeping a path from 100 to 300 yds. wide and destroying everything within its reach; 27 persons were killed and between 50 and 70 more or less injured. About 50 dwellings were destroyed, and the loss in buildings alone is estimated at $30,000. A settlement near Columbia, known as Macedonia, about 2 miles from the original striking point of the tornado, containing about 25 houses, was completely demolished, and 13 people were buried under the debris. After leaving Columbia the tornado cloud disappeared. Total distance traveled, 215 miles; time, 5 hours and 30 minutes.

Tornado No. 4 started about 6 p. m. in Williamson county, Tenn., a few miles south of Franklin; it passed through the town of Clovercroft and struck Nolandsville at 6.30 p. m., where 3 persons were killed and about 13 buildings destroyed. Passed through Lavergne, in the southeast corner of Davidson county, at 6.41 p. m., killing 2 persons and demolishing 25 buildings. As I have not been able to trace this storm beyond Lavergne it is probable it left the earth at that point. Distance traveled, about 25 miles.

Tornado No. 5 probably had its origin in the extreme southeastern portion of Arkansas, but first came into notice not far from the town of Huntington, Bolivar county, Miss., at 7 p. m. In the vicinity of Huntington 10 buildings were destroyed and about 20 persons injured. From Huntington the storm moved northeast and reached Cleveland in the same county at 7.50 p. m., wrecking a number of houses on the Sparkman and Coleman plantations and injuring a number of people. From Cleveland the storm passed through Sunflower and Tallahatchie counties, a few miles south of the path taken by No. 3, and disappeared near the town of Reynolds in the southeastern corner of Panola county, Miss., at 9.30 p. m. Distance traveled, 95 miles; time, 2 hours and 30 minutes, or about 40 miles an hour.

Tornado No. 6 started in Marshall county, Miss., near the town of Coyce, and, moving northeast, struck the town of Tracy. At the little town of Vance a general store and 10 cabins were destroyed and 3 children killed. The tornado then passed into Tennessee and reached Moscow, Fayette county, at 7.15 p. m. Here it destroyed the residence of Mr. J. Owens, seriously injuring the inmates, and also demolished several farm houses in the vicinity. This storm was distinctly seen from Memphis. Distance traveled, 24 miles; time, about 30 minutes.

Besides the tornadoes above noted, two occurred in northern Alabama, one between 6 and 7 p. m., and the other during the early morning of Nov. 21.

The money value of the property destroyed by these tornadoes cannot be accurately known, but it is certainly not less than half a million dollars.

A NOVEL METHOD OF BRIDGE ERECTION WITHOUT FALSEWORK.

In a recent paper before the Institution of Civil Engineers,* describing the design and construction of a railway bridge in Queensland, Australia, a novel plan for dispensing with falsework is shown which presents some features that may interest American engineers.

The bridge in question is designed to carry a single track of 3 ft. 6 ins. gage over the Burkedin river, a stream ordinarily of insignificant size but subject to sudden heavy floods. In 1870 the highest flood on record occurred when the cross-section of the stream at the bridge site was 81,250 sq. ft., with a velocity of nine miles per hour. As the bridge trusses had riveted connections and erection was a slow process, some plan of erection was needed for the channel spans which would avoid the risk of loss by heavy floods. This plan of erection is described in the extract from the paper printed below, and is illustrated in the accompanying cuts.

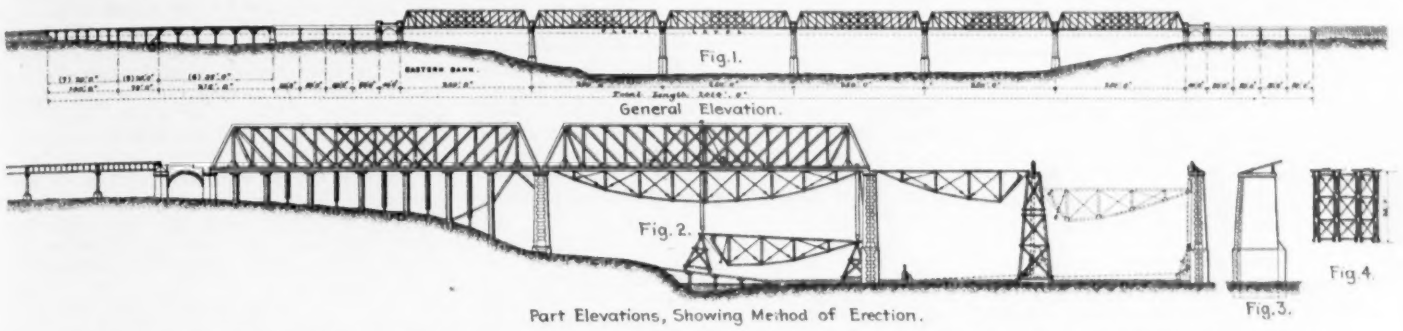
Other features of the structure, which are described quite fully in the paper, will be more curious than useful to American bridge designers. It may be noted, as an illustration of English methods of bridge construction, that all the material for the bridge was shaped, drilled and riveted in shops erected for the purpose at the bridge site. The plates, shapes, etc., were imported in the rough and hauled by wagon 70 miles to the bridge site. Under these circumstances it is not at all strange that nearly two years elapsed between the time work began on the structure and its final completion.

The general design of the bridge will be evident from the accompanying elevations. The six truss spans are each 246 ft. between centers of bearings, 30 ft. 9 ins. deep, with a panel length of 15 ft. 4½ ins., with the trusses spaced 15 ft. apart. The piers were built of concrete. The total weight of steelwork in the entire bridge was 1,163 gross tons. All rivet holes (the total number being estimated at 918,000) were drilled, no punching being allowed. The machines used were 8 radial drills, 6 vertical drills and one multiple drill. The radial drills averaged 250 holes each per day of 10 hours, at an average cost of 0.74 ct. per hole. Three pneumatic riveters were used, and while as much riveting as possible was done in the shop, the field rivets amounted to about 10% of the total. The total cost of the structure, including about 2½ miles of approaches, is given at £72,971.

The description of the method of erection given in the paper is as follows:

In reference to the erection of the steel spans, those over the eastern and western bank of the river, which were clear of the main channel, and the third span, which was erected during the dry season, were built on a timber falsework, Fig. 2, while the remaining three spans were built on a steel trussed platform spanning the complete opening, which was moved in sections from span to span as each was completed, Figs. 2 and 3. This platform, which was known on the works as the "temporary truss," was constructed of four light steel pin-trusses, each of 250 ft. span, with a central depth of 25 ft.; they were of bowstring form, and were placed parallel to each other, 7 ft. 6 ins. apart from c. to c. of chords, the lower curved chords consisting of wrought-iron eye-bars, and the upper chord of angle-bars and plates, the trusses being braced transversely with ⅞-in. tie-rods. The method of using and transporting the trusses is clearly shown in Fig. 2. A central timber pier was constructed between the two concrete piers, and the temporary trusses were hoisted, one-half at a time, the joint in the center being made with bolts and nuts. As soon as the four trusses were in position and jointed, and the transverse bracing secured, the work of erecting the permanent structure was commenced, while the temporary timber pier was withdrawn and moved to the next span. When the permanent work was sufficiently far advanced, the central joints of the temporary trusses were again broken and each half was lowered from the standing work on to two timber trestles placed in position to receive the ends; the trestles, with their load, were then moved transversely on to a tram line laid along the downstream side of the piers, by which means they were conveyed into position for hoisting in the next span. The weight of each temporary truss was 20 tons, and there were thus eight hoists of ten tons each, or 5 tons on the tackle at each end. The work of disconnecting and lowering the four complete trusses, moving from one span to the next, hoisting, and remaking the joints, occupied under favorable conditions three weeks.

The permanent work was erected on the temporary trusses by means of a traveling gantry built of squared Oregon, and the heaviest sections hoisted were the batter-braces weighing 3.28 tons each. The spans were built to a camber of 5 ins., the lower chords being accurately set to this camber with the level when first laid on the blocks, which had to be adjusted from time to time. In servicing the sections of the main trusses together, the lower chords were laid down first, accurately set to camber, and lined up; the posts and top chords were then hoisted into position, working from the center towards the ends, and finally the main ties, wind-bracing and deck beams were erected in the order named; the greatest difference in length between bottom chords when riveted was 3-16-in. in 246 ft.



Part Elevations, Showing Method of Erection.

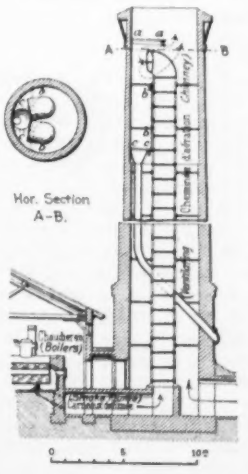
THE BURKEDIN BRIDGE, QUEENSLAND, AUSTRALIA. SIDE ELEVATION AND METHOD OF ERECTION OF CHANNEL SPANS.

*"The Design and Construction of Steel Bridge Works," by C. F. V. Jackson.

A GERMAN DUST ARRESTER AND VENTILATING CHIMNEY.

To provide the necessary power and heat for the Clinic Institute, at Halle, Germany, a battery of ten boilers is used with 688 sq. ft. of heating surface in each. Upon the grates under these boilers, says the "Centralblatt der Bauverwaltung," there has been burned for some years past a lignite of very impure quality. The thick smoke produced would have been a serious nuisance to the neighborhood had it been allowed to escape; but this was avoided in great part, as follows:

The two chimneys into which the products of combustion from these boilers are discharged are made up of a series of cast-iron rings, 4.92 ft. in diameter and 131 ft. high in all. These two chimneys are placed in the middle of a third chimney or tower built of brick masonry and 16.4 ft. inside diameter. The air in this third chimney is heated by radiation from the iron chimneys, and thus produces an energetic upward draft which is effectively used in ventilating the different rooms of the establishment.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AND
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ADVERTISING RATES: 20 *cents a line. "Want" and "For Sale" notices, special rates, see page XXI-XXIII. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.*

We remarked last week that the real motive force back of the deals and consolidations which have attracted so much attention of late is merely the desire to make profits. An interesting illustration of this has recently been made public in a suit brought by a stockholder of the Erie R. R. to restrain the voting trustees of that company from carrying out the agreement to purchase the Pennsylvania Coal Co., the Erie & Wyoming Valley Ry., and the Delaware Valley & Kingston Ry. As our readers will recall, these companies were bought in December last by J. Pierpont Morgan & Co., and turned over to the Erie R. R. In the pending suit, it is stated that the firm of Morgan & Co. bought these roads for $27,400,000, and sold them to the Erie for $37,000,000, thus making a profit of $9,600,000 on the transaction. In the defendant's answer to the suit it is claimed that the profits of the Morgan firm were only $2,300,000. Even this admitted profit seems a pretty stiff sum to saddle upon the long-suffering Erie stockholders. Did Mr. Morgan, as a voting trustee of the Erie R. R. Co., purchase from himself or from the firm of which he is the head these various properties at an advance of two to ten million dollars over the price which he or his firm had just paid for them? If such is the case, it is little wonder that deals and consolidations and "harmonizing" schemes are popular in Wall St. just now.

One of the important questions which this suit raises is whether the public should not have something to say concerning these numerous consolidations, to the end that stock shall not be liberally watered in the process. There is a pretty strong endeavor in these days of prosperous business to base capitalization on possible earning power, and not on actual investment in plant. Then by and by the cry will be heard that railway rates must be kept up to pay dividends to the innocent holders of watered stock.

If two and two made four in these gigantic consolidation deals, the chief incentive for their creation would disappear. It is because two and two make five or six or seven that addition—and division of the increment—is just now such a popular arithmetical exercise.

The commanding position of New York city as a financial center and its growing strength is indicated by the statement that on Feb. 16 the aggregate bank deposits reported to the New York clearing house for the first time passed the billion dollar mark, aggregating $1,011,329,000. The loans on the same date were $914,623,000. It must be remembered that this represents only the banks associated in the clearing house. The multitude of other banks, the trust companies, the savings banks and the great insurance companies with their large accumulations of funds are not included at all.

Another appeal of ex-Captain Carter to the United States courts for release from prison has been, very properly, turned down. His plea this time was that he desired to go to Savannah, Ga., to stand trial in the civil courts on the indictment found against him and his confederates a year ago last December. It is noticeable that his fellow-conspirators have not betrayed a similar anxiety to hasten to Savannah for trial! They have proved that (in their case at least) it is vastly more difficult to transfer a man arrested for crime from one part of the United States to another than it is to extradite him from a foreign country.

The law's delay in the case of these indicted contractors is becoming a national scandal; and the same may be said of the flagrant misuse of the writ of habeas corpus by Carter's attorneys to bring him before the courts again and again on trivial pretexts. When a criminal is convicted and sentenced, it is absurd to have the time of the courts taken up by repeated appeals from his attorneys. If Carter had shown himself a man, if he had confessed his crime in the face of the overwhelming proof, had restored to the government his share of the stolen money, had assisted in the conviction of his fellow-conspirators, and taken his punishment like a soldier, he might have regained in some measure the respect of his former associates. His endeavors to escape through legal technicalities the just punishment for his crime; and his hysterical, protestations of innocence in utter disregard of established facts, given out to the public at each fresh appearance in court, can arouse only contempt.

A great deal has been said in the newspapers respecting the intention of the New York Central R. R. to adopt some motor other than steam locomotives for propelling its trains through the long tunnel approach to the Grand Central Station in New York city. Glowing accounts have been published of the impending success of compressed air motors, hot water motors and electric motors; but it is easy to infer at the inspiration of some of these accounts. The real state of affairs seems to have been well set forth by Mr. A. M. Waitt, Superintendent of Motive Power of the New York Central, in a recent published interview as follows:

> No motor, operated either by electricity, compressed air, or hot water, has come within great distance of the requirements of the situation. The best was done on Feb. 1 by a compressed-air motor, which pulled one Pullman car eleven miles and got home just in time to save itself from being left powerless on the track. It did not exceed 20 miles an hour at any time in the run. It started with 3,000 lbs. of pressure in the reservoir, and at the end of the run had left less than 700 lbs. Its working pressure at the start was 180 lbs., but at the conclusion this had dropped to 75 lbs., just enough to make the wheels go round. Several years ago, at High Bridge, experiments were begun with a hot-water motor, whose power was generated from superheated water kept in a liquid state by strong compression. Although this motor was arranged in a car scarcely larger than a street car, it was not successful. Its principle has commonly been called "liquid steam." A new and enlarged model is approaching completion at present, and another trial will be given it soon. The fatal objection to electrical motors is that they require a third rail, which is out of the question in a great switching yard like that of the New York Central. I know of no great switching yard where electricity is in use as a power. The danger to men in a yard where there are a score of tracks which they must constantly cross and recross on foot, is too great to be considered.

Other reports state that electricity can be made to fill the bill by placing a storage battery upon the motor to furnish current for its movements from the station through the yards to the tunnel entrance; but the difficulty in making a battery which will furnish a very large current for a short time and within reasonable limits of weight are well known. Besides this, the delay in stopping to exchange the motor for a steam locomotive after passing out of the tunnel would be an almost fatal objection. Indeed, President Callaway has publicly stated that any motor to be acceptable must be capable of hauling a full-size passenger train all the way to Albany. The abolition of steam locomotives in the tunnel entrance to New York city is thus very far from being in sight.

If the New York Central really wants to improve the condition of affairs inside its tunnel, it should remodel the ventilation system on rational principles. Possibly objections of property-owners and municipal authorities make this impossible; but such objections are founded chiefly on ignorance and it ought to be possible to overcome them.

There are few places where it is easier or more common to waste power by bad design than in machinery for moving air. In some recent competitive bids for large fan blowers, the price of one manufacturer was $500 above that named by another. The low-priced bidder, however, estimated the power necessary to drive his machines at 50 HP., while the higher bidder, to whom the contract was finally awarded, succeeded in doing the work with an expenditure of only 10.5 HP. The whole secret in moving air economically is to keep pressures and velocities low. Sometimes space will not permit the large-sized apparatus necessary for this; but where space can be spared, the saving in power will much more than compensate for the added first cost.

A new field for philanthropists was suggested by Dr. Walter Wyman, Surgeon General U. S. Marine Hospital Service, in the course of an address delivered the other day at Havana, Cuba. He wonders that the list of public benefactions in the United States for 1900, placed at $61,000,000, includes "no mention of purely sanitary gifts or endowments." While we believe much more giving of this sort has been done than Dr. Wyman is aware of, its sum total is small beside the vast amounts contributed for religion and education. To name only one line of sanitary beneficence, if some multi-millionaire should provide the means for building municipal bath-houses all over the country as liberally as Mr. Andrew Carnegie is establishing public libraries, there can be no doubt that a vast amount of good would result.

THE INFLUENCE OF PORTABLE TOOLS ON WORKSHOP PRACTICE.

For more than a generation we have had at our bidding a faithful servant, who performed certain heavy tasks faithfully and well. No one suspected until a very few years ago that this servant was able and willing to perform a multitude of other tasks of a wholly different sort, and with a neatness and promptness heretofore unknown.

This useful servant is compressed air. We kept him working in tunnels and mines and quarries, churning down holes to be loaded with explosives, and he set the brakes on our passenger trains. No one thought of taking him into the machine shop and the foundry, the wood-working mill and the stone-cutter's yard and setting him to work there to relieve human muscle.

A dozen years or so ago, however, it was found that he could be harnessed to a light hand tool and made to drive it back and forth a thousand or more times in a minute. Similar tools to give a rotary motion followed close after, and our old servant was fairly established in his new career.

At the same time, as most of our readers are aware, a great variety of other new applications of compressed air have been made; but it is

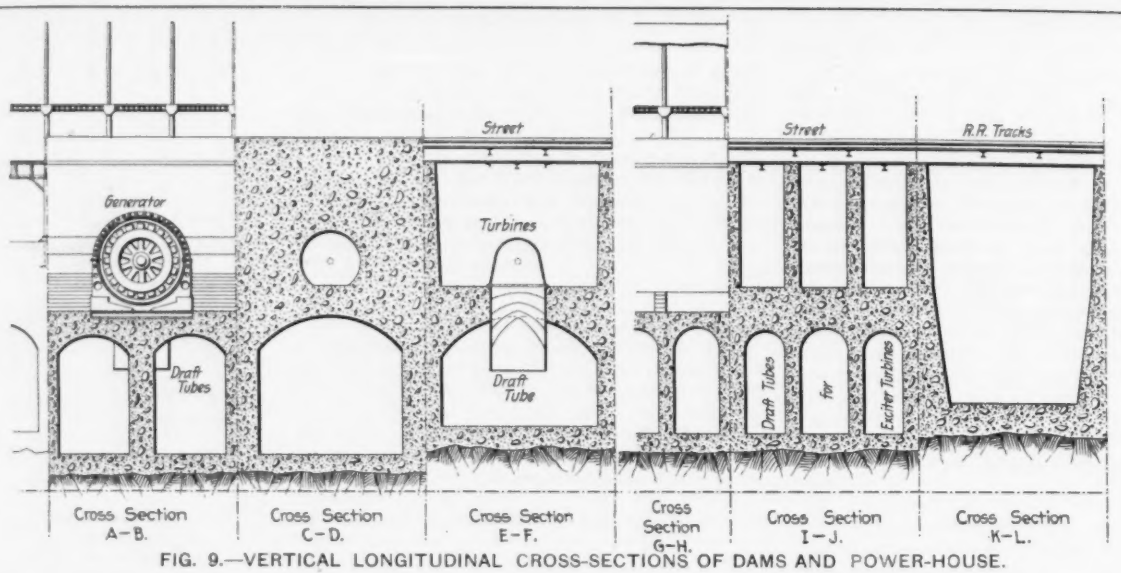


FIG. 9.—VERTICAL LONGITUDINAL CROSS-SECTIONS OF DAMS AND POWER-HOUSE.

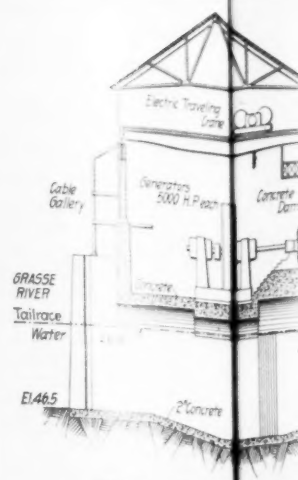


FIG. 8.—GENERAL CROSS-S

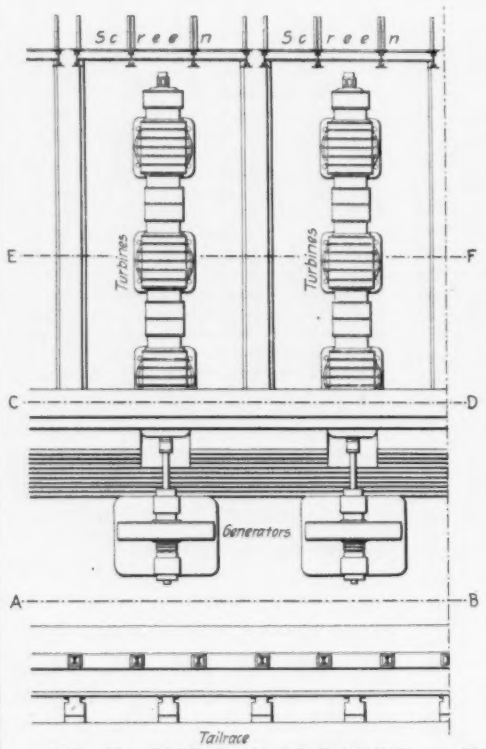


FIG. 10.—PART PLAN OF TURBINE CHAMBER AND GENERATOR ROOM.

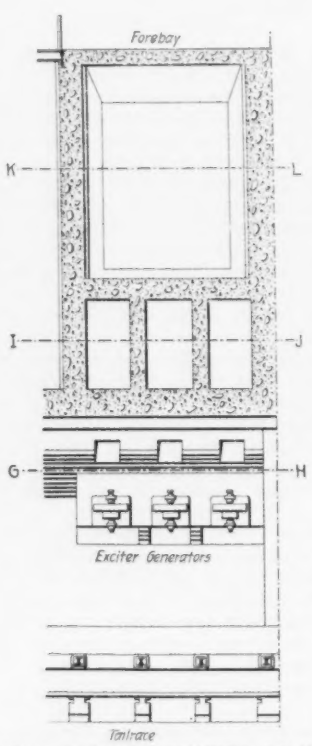


FIG. 10½.—PLAN OF EXCITER BAYS OF POWER-HOUSE.

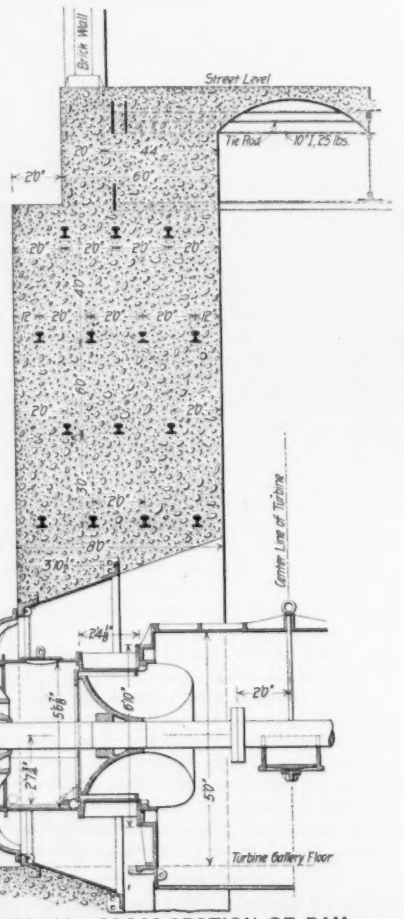


FIG. 11.—CROSS-SECTION OF DAM OPPOSITE CENTER OF TURBINE CHAMBER.

FIG. 14.—KETCH

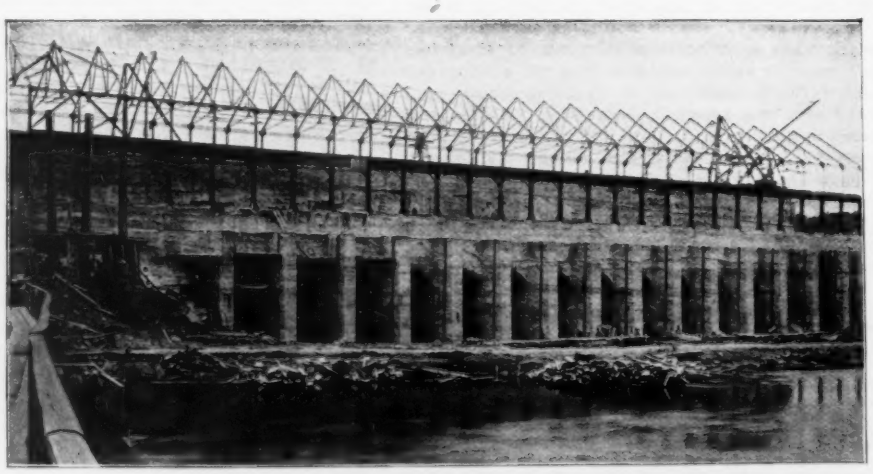
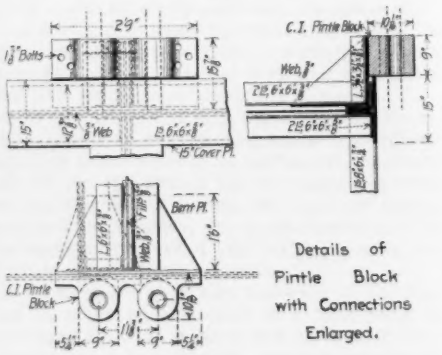


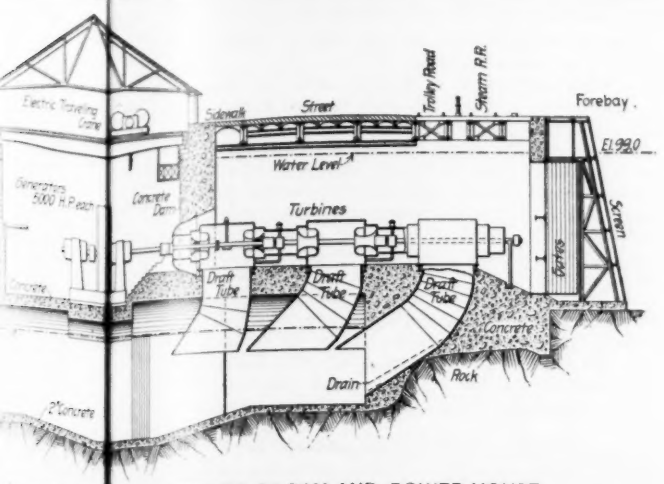
FIG. 13.—GENERAL VIEW OF MASSENA POWER-HOUSE ON TAILRACE SIDE.



Details of Pintle Block with Connections Enlarged.

POWER-HOUSE FOR WATER POWER PLANT OF THE S

John Bogart, M. Am. Soc. C. E., and Kincaid, Waller & Manville, Engineers.



B.—GENERAL CROSS-SECTION OF DAM AND POWER-HOUSE.

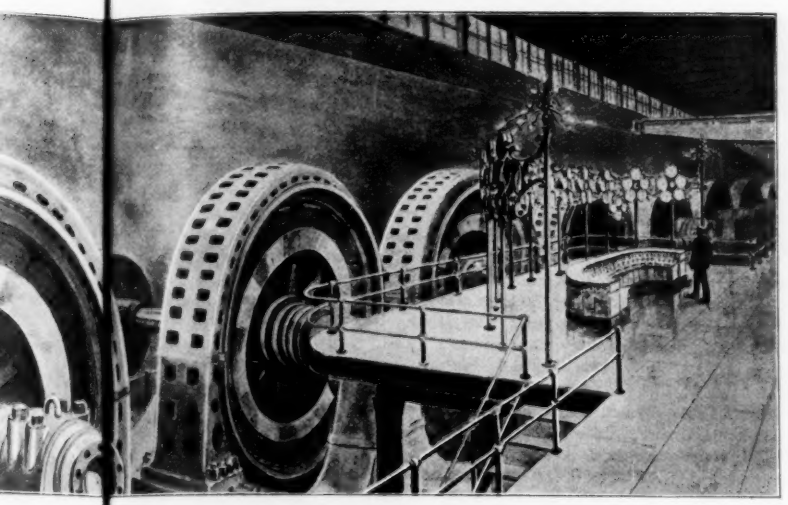


FIG. 14.—SKETCH OF INTERIOR OF MASSENA POWER-HOUSE, SHOWING CENTRAL REGULATING STAND.

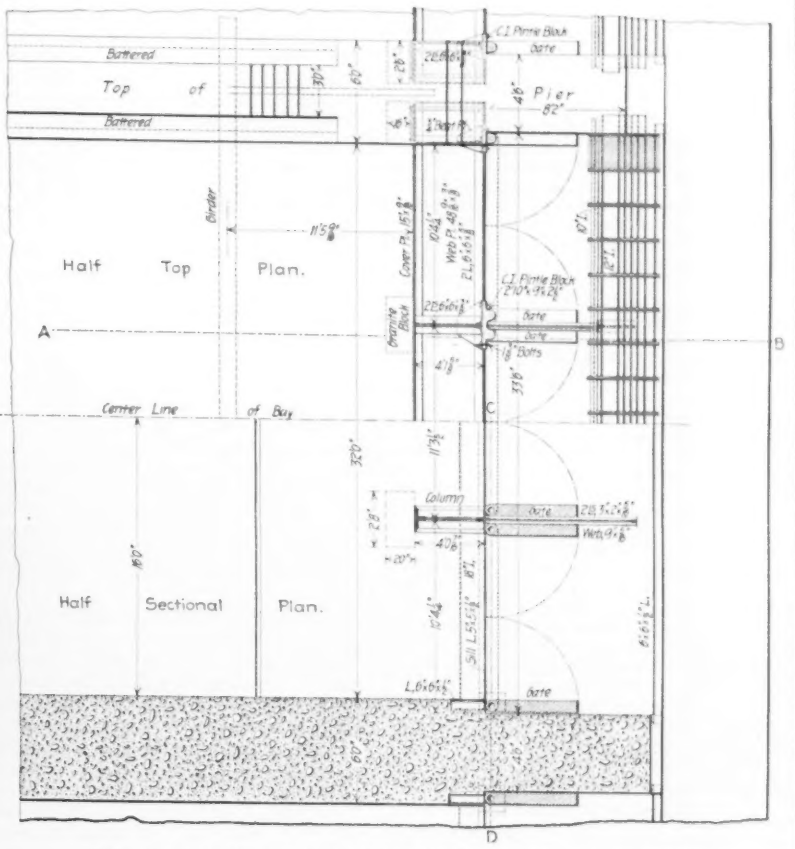
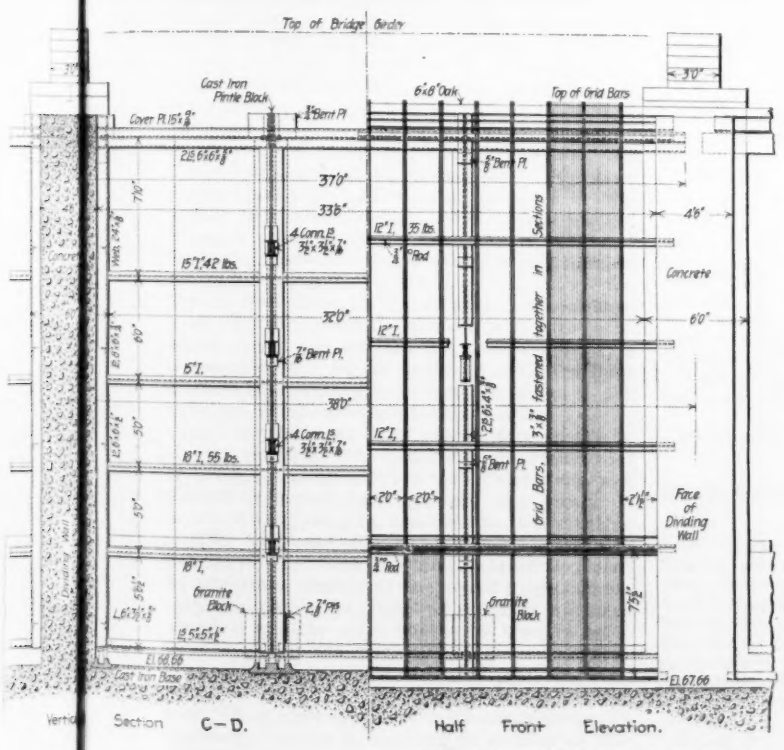


FIG. 12½.—SECTIONAL PLAN OF HEAD GATES AND SCREENS.



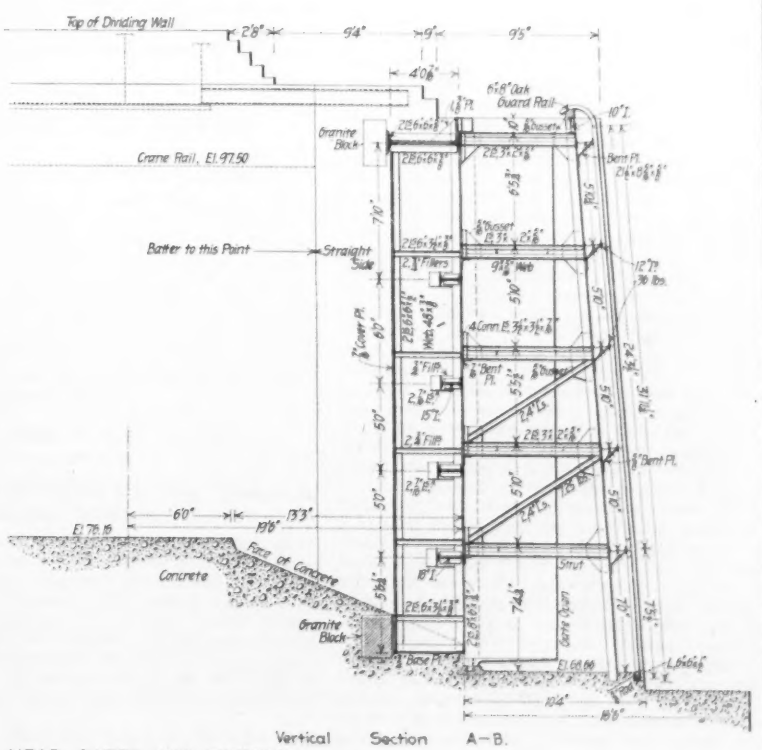


FIG. 12.—SECTIONAL ELEVATIONS OF HEAD GATES AND SCREENS.

ANT OF THE ST. LAWRENCE POWER CO., MASSENA, N. Y.
The T. A. Gillespie Co., Contractors.

doubtful whether any of them compare in industrial importance with its application to portable tools. A large number of these have now been designed and put upon the market, applicable to a very wide range of uses in special industries, and additions to the list are continually being made.

So far, the most important application of these tools has been to displace, or rather to increase the efficiency of, the hand workman. The file and the chisel, the chipping hammer and the calking tool, propelled by the blows of the hand sledge, are fast disappearing. In their place is heard the buzz of the pneumatic tool. These uses of compressed air are now familiar, and the matter to which we want to call attention is the further changes in workshop practice which seem likely to be brought about, and indeed are already appearing through the efficiency of these new portable tools.

In any manufacturing process, a question which must always be decided is whether the work shall be taken to the tool or the tool to the work. In the early days of manufacturing industry, when the use of machinery was in its infancy, and a factory was only an assemblage of workmen using hand tools, and aiding each other through division of labor, it was common practice to take the tools to the work. With the development of automatic machine tools to replace the hand tool in almost every process, it became necessary to reverse this system and take the work to the tool. Where the pieces to be worked were of large size and weight, this involved much difficulty, and in the olden times large expenditure of human muscle. It is not so long ago since the only equipment of a machine shop or foundry to handle the materials worked upon consisted of block and tackle or clumsy jib cranes, all worked by "main strength." We need hardly say that compressed air and electricity have changed all that. No modern manufactory doing heavy work is equipped for economical production without an outfit of pneumatic hoists and electric cranes, and this is often supplemented with something in the way of a general conveying system, perhaps in the shape of a shop railway operated by electric power.

These devices perform admirable service, and in many cases their use will be permanent. There are other cases, however, where the development of portable tools is likely to cause a return to the former practice. Instead of taking the work to the tool, it will again become common to take the tool to the work. It will be of interest to note some practical illustrations. One which has already become common and is familiar to most of our readers is the operation of riveting. The first power riveters (some of them still in use for places where a deep gap is essential) were ponderous machines, fixed in place, operated by hydraulic or steam pressure, and the work was, of course, brought to them. For every rivet driven, the heavy plate or boiler or whatever was in hand had to be swung to just the right position for the jaws to close down on the hot rivet. As we have remarked, such machines are still in use for work where a deep gap between the jaws of a machine is essential; but for all ordinary work the light portable pneumatic riveter which is taken to the work can be operated much more rapidly.

An illustration of more recent date occurs in foundry practice. The foundry is the department of machine construction where hand tools and hand work have longest retained their sway. It is only within the past dozen years that machine molding has come to have an important place in foundry work. With machine molding, however, an important change in the foundry system became necessary. The molding machine is a fixed machine, and the work had to be brought to it. That is to say, the machine had to be kept supplied with empty flasks and sand, and the completed flasks had to be carried off to the pouring floor. Thus some system of mechanical conveying frequently became a necessity to supplement the molding machine and enable it to work up to its capacity. These conveying systems often cost more to build and to operate than the molding machine itself. As those of our readers familiar with foundry work are aware, the chief work done by a molding machine is to ram or pack the sand in the flask. Recently portable pneumatic rammers have been developed, which in many places are claimed to do as good and more rapid work than the fixed molding machines. The tool is taken to the work again instead of the work to the tool. The flask is filled and rammed on the pouring floor, just as was done in the foundry before the introduction of molding machines, and the conveying of sand and flasks from the pouring floor to the machine and back to the floor again is no longer necessary.

Of course, there are classes of work where the fixed molding machine will still prove superior. There are others where the portable rammer will be a far more economical tool. It is the business of the managers to select the equipment best suited to their special conditions.

In general it will be evident that the portable tools will be of undoubted superiority on large and heavy work. The fixed machines will be equally certain of preference in shops where small repetition work is the chief output. The changes in workshop practice which we are discussing, therefore, will not affect the manufacturer of small articles. The workshops where such changes will take place are those where huge and heavy things are made—the boiler shops, the bridge works, the ship yards, the builders of heavy machinery. Here portable tools are already found in large numbers, and new fields for their profitable employment are all the time appearing.

We have thus far spoken chiefly of compressed air in connection with the development of portable tools, although electric power has also played some part in this work. The electric motor has the very considerable advantage for use in a portable tool that its supply of energy is derived from a flexible cable instead of a flexible hose, and it can be used, therefore, with a longer range from a fixed point and with less expense and difficulty in power distribution than compressed air. This advantage of electricity, however, is more than offset by the fact that electricity requires considerably more weight in the tool itself to give an equal blow or an equal torque with the compressed air tool, and this seriously interferes with the portability and rapid use of the electric tool. Besides this, small sizes of electric motors are so inefficient in use of current as to heat rapidly and become inconvenient to handle. Nevertheless, for special purposes, electricity may at times be the superior; and its possibilities should not be overlooked by designers and users of portable tools.

LETTERS TO THE EDITOR.

The Design of Roofs for Locomotive Roundhouses.

Sir: Referring to H. P. G.'s inquiry from Little Rock, Ark., about steel or wooden trusses for a roundhouse, I would say that a better roof construction than either of those mentioned is a composite construction of expanded metal concrete and steel. Such a roof is now under consideration for a locomotive engine house for one of the large railway systems of the East. In the expanded metal and concrete there is absolute immunity from fire; the sulphuric anhydride has no steel to attack as it is all inclosed in concrete, and there are no exposed roof trusses. The cost of construction is very low.

S. Saml. Berquist, C. E.

108 Wilson St., Brooklyn, N. Y., Feb. 18, 1901.

The Use of Cement and Vitrified Clay Water Conduits in Southern California.

Sir: I have read with much interest the article published in your issue of Jan. 17, relating to the 24-in. vitrified water conduit at Hartford, Conn., and your editorial reference to the same. While this is not the first time vitrified pipe has been laid as water conduit in the East, yet its use for this purpose has been insignificant compared with the opportunities where it would have been ideal construction. In Southern California this class of conduit has become standard wherever the conditions are favorable.

During 13 years' practice in this state the writer has specified and supervised the construction of over 100 miles of vitrified clay and cement concrete pipe conduit. Some of these lines have carried irrigation water only, others have been used for both irrigation and domestic water, while a few have been used for domestic water alone. They have ranged from 8 to 30 ins. in diameter, and in some cases portions of these lines have been under from 3 to 9 ft. pressure, with most satisfactory results.

The pipe has been laid to grade and joints made of cement mortar (1 to 2) without the use of gaskets, except in a few cases where lines would be under pressure. Stakes were set in the ditch, at each 25-ft. point, and the grade made to conform thereto. Vitrified pipe rests on the bells, while the cement pipe has a bearing its whole length. Much of the success of this class of work depends upon the care taken in backfilling. In this warm climate it is necessary to cover the joints, when completed, with earth, and the greatest care must be exercised, especially with the smaller sizes, lest the pipe be moved and the cement joint injured. The ditch is left open for not less than 10 days and often for 60 when new and unseasoned cement pipe is used. Usually water is turned into the lines and they are tested to full capacity for a few days, during which time they are thoroughly inspected and leaks, if any, stopped; after which the backfilling is completed.

The leakage of well laid cement or vitrified conduit is insignificant, and its length of life is undoubtedly greater than that of cast iron, while from the "standpoint of cost," the former has great advantage. The writer's practice is to use cement or vitrified conduit whenever water is to be conveyed without pressure, and the line can be laid wholly in excavation. The pipe should never be laid on embankment, but may be carried over narrow gulches on masonry arches, and wide ravines may be passed by means of metal or wooden inverted siphons.

As to the relative merits of cement and vitrified water conduits the writer's judgment is that they are equally meritorious. In making a selection for any given locality, vitrified pipe is used when it can be delivered on the ditch line at a price not exceeding the cost of cement pipe, manufactured on the ground.

The advantages claimed for this class of construction may be enumerated as follows: The carrying capacity remains a constant; the first cost is moderate; its durability is unequalled; and the adaptability to all classes and conditions of ground is appreciated only after a considerable experience in its use. Respectfully,

F. E. Trask, M. Am. Soc. C. E.

Douglas Building, Los Angeles, Cal., Feb. 8, 1901.

New Light on the Glover Septic Tank and Filter Bed Claims at the County Farm, Brentwood, N. H.

Sir: The communications in your issue of Feb. 7 from Mr. J. N. McClintock, C. E., and also from Jos. O. Osgood, M. Am. Soc. C. E., and the previous matter published in regard to the so-called Glover patents for septic tanks, have interested me considerably, as I am pretty well informed in regard to the history and the results obtained at the Brentwood, N. H., sewage disposal works.

Previous to the spring of 1895 the sewage from the Rockingham Co. farm buildings, which are located in the town of Brentwood, N. H., was discharged into a small brook, which flows nearly through the center of the town of Brentwood, and also nearly across the adjoining town of Exeter, emptying into the Exeter River within the limits of Exeter village. This discharge had created an intolerable nuisance. Citizens living near the stream had made bitter complaints, but as no united action had been taken, the county authorities and state board of health had done nothing. In November, 1894, I was elected a member of the state legislature to represent the town of Brentwood, and by vote of the town was authorized and empowered to, in whatever way I found most expedient, abate this nuisance; either by a suit against the county authorities, by an act of the legislature to cover the ground, or otherwise. Thinking it better to settle the matter amicably, if possible, I waited upon the county commissioners, informed them of the action of the town, and told them that while I much preferred to make an amicable arrangement with them, that unless they indicated their willingness to at once enter into such an arrangement I should immediately proceed to abate the nuisance. They threw themselves at once upon my mercy, and expressed a willingness to adopt an arrangement that would be satisfactory to me as the agent of the town. While the question of ways and means was being discussed, Mr. Glover appeared upon the scene. He was a fluent talker, and impressed the commissioners with his ideas, and finally offered to construct, at his own expense, a disposal works combining a system of septic tanks (as now known.—Ed.) with filtration, guaranteeing that the effluent should be 95% pure, and stipulating that when this plant was completed to the full satisfaction (purity of effluent included) of the commissioners, he was to receive $800. If all of the conditions were not complied with, he was to receive nothing. Without consulting me the commissioners agreed to this arrangement. I afterwards assured them that the principles involved were mainly correct, and that they were in operation elsewhere; that if properly constructed I would, for the town, accept the result and withdraw any further demands. But I assured them that any such purity as was promised was entirely preposterous. During the season of 1895 I was in the employ of the water board of Manchester, N. H., and had very little time to spend elsewhere. Consequently I did not get much opportunity to look after Mr. Glover's methods of construction. He completed (or said that he had so done) the work late in the season, and asked for its acceptance. The commissioners, however,

decided to wait a while, and see how the thing operated. They had, during construction, been obliged to furnish a considerable amount of the material and labor used, as Mr. Glover's capital proved to be very limited. For a few months the plant worked after a fashion; at least, the water came through it, but not 95% pure. Before the end of the first year it, notwithstanding the fact that every precaution of raking off the filter beds and renewing the surface sand was taken, became completely clogged. In the spring of 1897 a new board of commissioners came into power. Mr. Glover had died during the year, and Mr. McClintock, who had acquired whatever Mr. Glover possessed in the way of patents, made a demand upon them for payment. When informed of the condition of affairs Mr. McClintock offered to put the plant into running order, provided the commissioners would agree to terms that he proposed; among them, an acknowledgment of all that he claimed was included in the alleged Glover patents. This the commissioners declined to do, and subsequently employed the writer to overhaul and to put the plant in order. Upon investigation I found the filtration portion (originally entirely inadequate) completely solidified. Under the sand which formed the surface, unwashed and unscreened gravel, with a considerable admixture of loam and clay, had been used, and this had completely clogged the bed. The main pipe leading from the buildings was over a foot lower, 50 ft. from the outlet into tank No. 1 than at this outlet. Other portions were similarly constructed, necessitating a complete reconstruction. The pipes were all relaid. The area and capacity of the filter beds was doubled, and material suitable for such purposes used in their construction. The tanks were the only portion of Mr. Glover's work retained. The plant, as reconstructed, has done good service, but has never discharged an effluent 95% pure, and never will do so. Mr. McClintock has corresponded quite extensively with the commissioners of Rockingham Co., and in various ways tried to get from them some acknowledgment of his claims. He has sent several parties there, ostensibly to inspect the plant, but has so far failed to get any acknowledgment of value to him. We have no desire to prevent or hinder his ambition to establish "Mr. Glover's fame or his company's rights," but consider Brentwood a poor locality in which to accomplish either.

Yours truly,

Arthur W. Dudley, C. E.

936 Elm St., Manchester, N. H., Feb. 11, 1901.

Notes and Queries.

A. E. C., Havana, Cuba, writes:

"Will you please enlighten me, if you have any data giving the information, as to the thickness of concrete wall required to prevent percolation of water through the same under a static head of 16 to 20 ft. The concrete is of these proportions: Portland cement, 1 part; sand, 3 parts; broken stone, 5 parts."

All concrete is more or less porous, and if absolute water tightness is required a layer of waterproofing material, such as asphalt or petroleum wax must be used, or the wall must be given some coating which will fill the pores. Articles describing such waterproofing work were published in our issues of April 5 and Sept. 6, 1900.

THE CAR JOURNAL BEARING AND HOT BOXES.*

By S. P. Bush.†

It is desired to call attention to a condition which cannot fail in many instances to produce a hot box. Take for example the M. C. B. Standard 60,000 lbs. capacity journal and bearing. The journal has a diameter of 4¼ ins., while that of the bearing is a trifle greater. The bearing has a lining or filling of lead or soft composition metal, so that when put together into service, all things being as they should, the bearing very soon adjusts itself to the journal.

As the journal continues in service, it wears until it reaches the limit of 3¾ ins., so that it is not far out of the way to say that the average journal under 60,000-lb. cars is 4 ins. diameter. But during the life of the journal many bearings are applied to it, and usually it is the standard bearing intended properly for a journal 4¼ ins. diameter. Thus a considerable difference exists in the radii of surfaces that should be nearly alike, and this difference grows constantly greater as the wear of the journal continues. The result of such difference is illustrated in Fig. 1.

While it is expected, and is sometimes the case, that by reason of the soft metal filling the bearing will gradually adjust itself to the journal, yet when we consider the very small bearing area that we must have for some time, and the resultant intensity of pressure per unit of area, is it reasonable to expect that hot boxes should not frequently result, and as a matter of fact do, when new bearings are applied?

Think of these conditions in fast passenger service. Not only is the adjusting of the bearing to the journal in itself an operation likely to give trouble, but in addition, as the adjustment progresses, the journal box, key and bearing move downward with relation to the axle, with the consequent tendency of dropping the packing away from the under side of the journal and thus cutting off the supply of the lubricant.

It is hardly possible in practice to provide satisfactory relations between the worn journal and a new bearing from the beginning, but the writer presents a plan as shown by Figs. 2 and 3, which has been found a decided improvement. The inner surface of the bearing is provided with a raised strip on either side of center line and parallel with it.

These strips are from ⅝ to ¾-in. wide and directly under the edges of the flat horizontal surfaces of the key and bearing, so that there is little tendency to spread the brass. They are raised above the inner surface enough only to provide three lines of contact between the bearing and journal when the latter is worn to 3¾ ins., as per Fig. 3. This gives two lines of contact when the journal is full sized, as shown by Fig. 2. Engine truck journal bearings on a similar principle have been used for years with great success.

Besides providing a better adjustment more rapidly, a further advantage is gained in preventing so much movement of the axle in the bearing at right angles to its axis, such as may be caused by an application of the brake, or in passing around curves, so that the axles are more apt to be maintained parallel with each other. As a better contact between journal and bearing is provided from the beginning, the tendency for the packing to drop away from the under side of the journal is also reduced, and it will thus be seen that the opportunities for hot boxes are lessened.

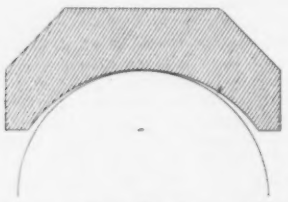


Fig. 1.—New Bearing Applied to Worn Journal.

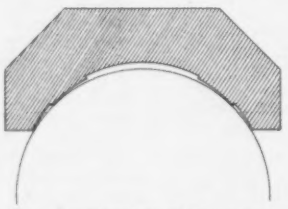


Fig. 2.—Bearing with Raised Strips Applied to New Journal.

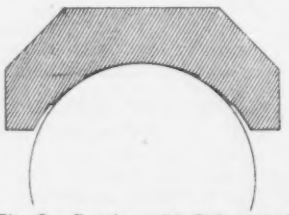


Fig. 3.—Bearing with Raised Strips Applied to Worn Journal.

*Abstract of a paper read before the Western Railway Club, Dec. 18.

†Superintendent of Motive Power, Chicago, Milwaukee & St. Paul Ry., Milwaukee, Wis.

SANITATION AND PROGRESS.*

By Dr. Walter Wyman.†

Each morning I open on my official desk a package of newspaper clippings containing notices of the prevalence of the several contagious diseases throughout the whole United States, and, as I note the varying recurrence of smallpox, diphtheria, typhoid fever and scarlet fever, the notes upon consumption, the alarms concerning yellow fever and the bubonic plague, the thought which is impressed upon me is how seriously are we lacking in proper effort in suppressing these suppressible diseases.

Why do these diseases persist? The answer is plain. It is that sanitary administration has not kept pace with scientific knowledge. It is also evident that this scientific knowledge is not so widely diffused as it should be, even among those of whom we have a right to expect it. It is evident that we are not making "use of those means which the God of nature has placed in our power."

A good water supply, perfect sewerage and disposal of garbage, good street paving and street cleaning, should be the first boast of every municipality. Let these be pointed to with the pride which is commonly bestowed upon great public institutions and buildings. I see no reason why slums should be allowed in any city. Relatively speaking, too much attention is paid to public parks and handsome municipal buildings. The city's improvements should be in the alleys, around the docks, in the tenement house quarters, and, great as may be the appreciation of public art as manifested by statues and public gardens, and of the parks and boulevards, let these wait upon the less showy but more important features of municipal life.

It is an interesting matter for conjecture—what would be the effect upon the prevalence of contagious disease if there could be a complete wiping out of all slums and low tenement house districts in all our cities?

A class of men to whom we should look for aid is the men of extreme wealth. I believe their attention should be directed to the vast amount of good to be done by the employment of their capital in backing up sanitary improvements. The number of great fortunes possessed by individuals in our several republics I have noted and the opportunity of learning, but they are numerous and so far as I can judge, their possessors, at least a large number of them, are imbued with generosity and a desire to utilize their great wealth for the public good. Witness the large number of universities founded by wealthy men, the public libraries and other institutions founded or endowed by them; the contributions which they make in times of great calamity and in ordinary times to all charitable undertakings.

In a recent press clipping I have read that statistics just compiled show that during the year just passed contributions to educational, religious and charitable objects and institutions in the United States have amounted to almost $61,000,000, donations of less than $1,000 not being included in this summary. The article further states that this showing seems to indicate that there is a growing disposition to make philanthropy a partner to prosperity, a tendency to give helpfully instead of pauperizing men by benefactions. But in the list of these benefactions I see no mention of purely sanitary gifts or endowments, and to my mind it seems a reasonable proposition that more practical and beneficial results would have been obtained if this $61,000,000, instead of being expended upon educational, religious and charitable institutions, had been expended upon reclaiming the slums and in the purchase and destruction of rookeries, with the erection in their stead of modern sanitary tenement houses, and that, too, even though the money had not been expended outright as a gift, but as a safe though moderately paying investment.

*Abstract of an address before the Pan-American Congress, Havana, Cuba, Feb. 6, 1901.

†Surgeon General, U. S. Marine Hospital Service.

BOOK REVIEWS.

THE COPPER HANDBOOK.—Giving 50 statistical tables, thoroughly covering Lake Superior copper production, values, prices, dividends and assessments; the capitalization, fluctuations in prices and transfers of shares of Lake Superior copper companies; copper production, consumption and exports of the United States; the English copper trade; the world's copper production and other tables. Also, detailed descriptions of all Lake Superior copper mines, showing location, area, officials, production, lodes, shafts, machinery, mills, railroads, buildings, forces, copper percentages, and much other information of value. Compiled and published by Horace J. Stevens, Houghton, Mich., 1900. Paper, 6 × 8¾ ins.; pp. 328.

The compiler has set forth the scope of his work so fully in his title that little is left to say on this head. He has gathered together a vast amount of material concerning copper production in the United States, though his authorities for this information are not noted. He says, however, that painstaking effort has been made to verify his statements and figures and he proposes an annual edition hereafter.

THE COAL AND METAL MINERS' POCKET-BOOK.—Principles, Rules, Formulas and Tables. Especially compiled and prepared for the convenient use of mine officials, mining engineers, and students preparing themselves for certificates of competency as mine inspectors or mine foremen. Sixth edition, revised and enlarged with original matter. Scranton, Pa.: The Colliery Engineer Co. Leather; 4 × 6½ ins.; pp. 637; illustrated. $2.75, or in cloth, $2.

The last edition of this useful pocket-book has been thoroughly revised and much new matter added, under the united advice and with the efficient aid of the staff of "Mines and Minerals" and that of the large professional staff of the International Correspondence Schools, of Scranton. Its pages well cover the needs of the particular class referred to in its title: from the simpler and rudimentary information to the higher and more intricate demands of a many-sided profession. Broadly stated, it includes principles, rules and formulas in all that relates to weights and measures, the applied mechanics of mining, forms of power, and the practice of mining. Further, it is well arranged and clearly printed; has a long and useful glossary of mining terms and a good index.

A TEXT-BOOK ON FIELD FORTIFICATION.—By G. J. Fiebeger, Professor of Civil and Military Engineering, United States Military Academy. New York: John Wiley & Sons. Cloth; 4½ × 8¼ ins.; pp. 166; illustrated. $2.

Field fortification deals with all defensive works of a temporary character—as contrasted with the permanent works leisurely build by a state to secure permanent possession of important strategical positions. And to realize the changed conditions in planning these field works—of hasty or more deliberate construction—we have only to note that up to 1840 the infantry arm had remained practically unchanged for 300 years. Until 1840 armies used the flint-lock, smooth-bore, muzzle-loading musket; that had an effective range of only 250 yds.; that was uncertain in action and could not be fired oftener than one and one-half shots per minute. In 1855 this weapon was replaced by a percussion-lock, muzzle-loading rifle, that extended the danger-zone to 500 yds., but could not be fired faster than the old musket. The breech-loading rifle came into use in 1869, and this was sighted to 1,300

yds., and 12 shots could be fired in one minute; but even this great advance in range and rapidity of fire is eclipsed by the small-caliber, magazine rifle of the present day; fired with smokeless high-power powder that gives a range of over 2,000 yds., and a mechanism that admits of 20 shots being delivered in one minute. With the evolution of the infantry arm there has been a corresponding development in field artillery; in range, rapidity of fire and destructive efficiency. Under such radical changes in the conditions of warfare it is little to be wondered at that methods of defence, that became classical through the practice of three centuries, no longer avail. In this work the author discusses modern requirements and methods; and illustrates the principles laid down by extended detail of actual operations in modern wars. The several chapters cover the methods of defence—in the open field, in buildings, villages and towns and at river crossings. The engineering side is a most important one; and with the plan necessary and tools used in carrying out these plans, we have the use of explosives in destroying structures in war, the sanitary arrangement of camps, the building of roads, etc. While purely military in its purpose, the work has a side that is interesting to engineers; and the knowledge acquired in its study may at any time be applied for a common benefit.

ENGLISH AND AMERICAN LATHES.—By Joseph G. Homer, A. Mem. Inst. Mech. Engrs. London and New York: Whittaker & Co. Cloth; 10 × 12 ins.; pp. 116; 300 illustrations. $7.

This book consists of more or less detailed descriptions of engine lathes as manufactured by various English and American firms. It has been written for the especial edification of our "good humoured" British cousins, as may be inferred from the following extract from the preface:

> The reason for its publication is the growing importance of the American lathe trade in England, and the consequent interest with which the distinctive features of the lathes of both countries are regarded. A few years since this subject was generally viewed with indifference, and the common sentiment felt was that of good humoured depreciation of the American type in this country. Now, it has found its abiding place in large numbers of our shops; an increasing number of agents here cater for its supply; it is advertised freely in the English journals; and several English and German firms manufacture copies of it, while others adopt some of its details.

However, the book should be of considerable interest to the American reader as well, since a comparison of different types will probably suggest opportunities for improvement in design. Details of construction are taken up quite exhaustively and the machines described are of the latest patterns. Although many of the devices shown may be familiar to the lathe designer, the book will undoubtedly be of value to the engineer and the machine-shop superintendent, as it will give them a comprehensive view of the present state of the industry. The nature of the contents of the book may be inferred from the following titles of some of the chapters: Lathes and Their Development; The Forms of Lathe Beds and Standards; Headstock Details; Heavy Lathes; Turret or Capstan Lathes; Special Lathes. The appendix gives in tabular form the principal dimensions of the machines manufactured by the leading English and American firms.

BRICKLAYING.—By Owen B. Maginnis. Published by the Author, 310 W. 128th St., New York city. Cloth; 6 × 9 ins.; pp. 85; illustrated. $2.

While the laying of bricks is among the oldest of the crafts practiced by man, an up-to-date work devoted solely to the methods of using bricks is something new in technical literature. Mr. Maginnis evidently writes from the standpoint of an experienced bricklayer, and in these pages he states what he claims to be the latest practice of his craft. He first describes the bricklayers' tools and the method of handling them; and then proceeds to the setting out of the work, measurements and levelling. The mixing of mortars and concrete come next, and this is followed by notes on the bonding of walls of various thicknesses; the building of angles, corners and intersecting walls; the varying bonds for face work, and the setting of terra-cotta details, brick arches, lintels and piers and hollow walls, and the building of chimneys, flues, etc. The anchoring, bracing and furring of brick walls and the fireproofing of wood floors, partitions and doors are discussed; and then follow chapters upon the scaffolds used by bricklayers, and the tackle and appliances essential to the conduct of the work. In connection with these separate articles useful tables are introduced. The concluding part of the book is devoted to shoring, needling and underpinning old and new buildings, in the processes of protecting adjoining structures, deepening foundations, or changing the face construction. There is a large amount of useful and generally novel information in this book; information of the kind that usually belongs to the craftsman alone, as the result of experience, and is seldom put into the shape of literature. A good index, however, would have added to the usefulness of the publication, as a work of reference. We regret to say that the printers' and binders' work on the volume is very poorly done.

U. S. GEOLOGICAL SURVEY.—Twentieth Annual Report. ington, D. C. 1900. Cloth; 7¾×11⅝ ins.; illustrated. Charles D. Walcott, Director. In Seven Parts. Wash- Part II., General Geology and Paleontology; pp. 953; plates 193. Part III., Precious Metal Mining Districts; pp. 595; 77 plates and 79 figures. Part IV., Hydrography; pp. 660; 75 plates and 222 figures. Part V., Forest Reserves; pp. 498; 149 plates with folding maps in separate cover. Part VII., Explorations in Alaska in 1898; pp. 309; 38 plates, 25 maps and large folding map in pocket. Map of Alaska showing gold-bearing rocks, with descriptive text and routes to the gold fields. Paper; 6 × 9 ins.; pp. 44; folding map. Preliminary report on Cape Nome Gold Region, by Frank C. Schrader and Alfred N. Brooks, Assistant Geologists. Paper; 6 × 9 ins.; pp. 56; illustrated.

AVERAGE COST OF ASPHALT PAVEMENTS IN 47 CITIES DURING 1900.

An interesting and valuable collection of asphalt statistics has been made by Mr. F. V. E. Bardol, Chief Engineer of the Department of Public Works of the city of Buffalo, N. Y. Through the courtesy of Mr. Bardol, we are enabled to present his compilation of the figures in the accompanying table. While the primary object of the statistics is to show the cost of asphalt in the United States and Canada during the past year, the table does much more than that, containing facts as to the governing features of the work, such as thickness and cost of foundation, thicknesses of binder and wearing surface, hours and wages of laborers. Besides the cities included in the table, returns were received from nine stating that no asphalt was laid by them in 1900.

It will be noticed that Mr. Bardol has attempted to put the figures on a comparative basis by making allowances in the itemized prices wherever the conditions reported differed from those in Buffalo. Thus, asphalt pavements in Buffalo cost $2.20 per sq. yd., while in the 47 cities they cost $2.29, on the face of the returns, and $2.41 when the items were converted to the Buffalo standards of quality and thickness of concrete, thickness of asphalt, hours and wages of laborers. On the Buffalo basis, the lowest figure obtained was at Winnipeg, Man., where the work was all done by the city, and the next lowest at San Francisco, the respective costs being $1.76 and $1.88 per sq. yd. The highest cost was at Boston, Mass., $3.20, and the next to the highest, Brooklyn borough, $3.08. It would be interesting to know whether the Winnipeg figures allow anything for interest, sinking fund and depreciation.

AVERAGE COST OF ASPHALT PAVEMENTS IN 47 CITIES, AS LAID IN 1900, INCLUDING BASE, BINDER AND WEARING SURFACE.

(Compiled by F. V. E. Bardol, Buffalo, N. Y., January, 1901.)

Cities.	Concrete: Average price.	Concrete: Thickness, ins.	Concrete: Proportions.	Concrete: Cost per c. yd.	Concrete: Correction.*	Kind of cement.	Cost: Cement per bbl.	Cost: Sand per c. yd.	Cost: Broken Stone per c. yd.	Binder: Depth ins.	Binder: Correction.*	Wearing surface: Thickness ins.	Wearing surface: Correction.*	Guarantee: Period, yrs.	Guarantee: Correction.*	No. of bidders.	Labor: Hours of labor.	Labor: Prevailing wages (common).	Labor: Correction*	Price per sq. yd.*	Engineer.	See note.
Altoona, Pa.	$2.47	6	1:2:5	$4.20	— .14	Natural.	$0.80	$1.55	$1.68	1	+ .10	1½	+ .19	5	+ .15	2	10	$1.60	+ .04	$2.81	Harvey Linton	..
Atlanta, Ga.	2.83	6	1:2:4	4.50	— .10	"	1.00	.75	1.25	1½	0.00	1½	+ .19	10	0.00	2	10	1.00	+ .10	3.02	R. M. Clayton	..
Baltimore, Md.	2.18	6	1:3:5	3.30	0.00	"	1.00	.75	1.50	1½	0.00	2	0.00	5	+ .15	1	8	1.66	0.00	2.33	B. T. Fendall	..
Boston, Mass.	3.25	6	1:3:7	4.50	— .24	Portland.	2.50	1.30	1.70	1½	0.00	1½	+ .19	10	0.00	2	9	1.75	0.00	3.20	B. T. Wheeler	..
Brooklyn, N. Y.	3.15	5	1:3:6	5.63	— .17	Portland.	2.20	75—80	1.60	1	+ .10	2	0.00	10	0.00	3	8	1.50	0.00	3.08	Geo. W. Tilson	..
Buffalo, N. Y.	2.20	6	1:2:5	3.30	....	Natural.	.70	1.25	1.10	1½	....	2	....	10	....	....	8	1.50	....	2.20	F. V. E. Bardol	..
Chat'nooga, Tenn.	2.68	6	1:2:5	....	0.00	"	....	....	....	....	....	2½	— .19	5	+ .15	1	..	....	....	2.64	Robert Hooke	..
Cincinnati, O.	2.05	6	1:2:6	2.60	— .03	"	.60	.75	1.35	½[4]	+ .10	2	0.00	5	+ .05	3	10	1.50	+ .05	2.32	N. J. Stanley	..
Cleveland, O.	2.17	6	1:2:4	....	0.00	"	....	....	....	1	+ .10	2	0.00	10	0.00	3	..	....	....	2.27	James Ritchie	..
Columbus, O.	2.20	6	1:2:4	3.00	— .11	"	.80	1.00	1.10	1	+ .10	2	0.00	10	0.00	3	10	1.50	+ .05	2.24	J. Griggs	..
Denver, Colo.	2.13	6	1:2:4	4.50	— .20	"	1.25	.50	2.00	1	+ .09	2	0.00	5	+ .15	3	8	1.60	0.00	2.17	W. P. Jones	..
Des Moines, Ia.	1.96	4½	1:2:4	....	+ .10	"	....	.40	1.25	1	+ .10	1½	+ .19	7	+ .09	2	10	1.75	+ .02	2.45	G. E. Eberhardt	..
Detroit, Mich.	....	0	1:2:4	....	— .07	"	....	....	....	1	+ .10	2	0.00	10	0.00	2	..	....	0.00	....†	R. H. McCormick.	A
Erie, Pa.	2.30	6	1:2:5	....	0.00	"	....	....	....	1½	0.00	1½	+ .19	10	0.00[5]	3	..	....	0.00	2.49†	B. F. Briggs.	..
Fort Wayne, Ind.	2.40	6	1:2:5	....	0.00	"	....	.65	1.15	1½	0.00	2	0.00	10	0.00	2	10	1.50	+ .05	2.45	F. M. Randall	..
Grand Rapids	1.75§	6	1:2:5	....	+ .10	"	.70	.40	1.00	1	+ .10	2	0.00	10	0.00	2	10	1.50	+ .05	....†	G. M. Ames	B
Kansas City	2.12	5	1:2:5	....	+ .03	"	....	.80	1.00	1½	0.00	1½	+ .19	10	0.00	3	8	1.40	+ .03	2.37	R. M. Waddell	..
Lafayette, Ind.	2.00	6	1:2:6	4.00	— .11	.....	....	....	....	1	+ .10	1½	+ .19	10	0.00	3	10	1.50	+ .05	2.23	W. K. Eldridge	..
Los Angeles, Cal.	1.80	6	1:3:6	6.00	— .21	Portland.	2.50	.40	1.00	No.	+ .28	2	0.00	No.	+ .18	1	10	2.00	—.01	2.04	F. M. Olmstead	..
Milwaukee, Wis.	1.85	6	1:2:5	....	+ 04	Natural.	.55	.65	1.10	1	+ .10	2	0.00	5	+ .15	3	10	1.50	+ .05	2.19	Chas. J. Poetsch	C
Minneapolis	....	....	6	1:2:5	3.00	0.00	"	.80	.55	1.35	1	+ .10	2	0.00	..	....	...	8	1.75	—.04	....†	G. W. Sublette
Montreal, Que.	3.25	6	1:3:4	6.00	— .45	Portland.	2.84	.75	1.25	½	+ .19	2½	— .19	10	0.00	1	10	1.25	+ .07	2.87	John R. Barlow	D
Newark, N. J.	2.03	6	1:3:7[2]	....	0 00	Prt. & N.	....	....	....	1½	0.00	2	0.00	10	0.00	2	..	....	....	....†	Ernest Adam.	..
New Orleans, La.	2.50	6	1:3:7	8.00	— .40	Portland.	....	2.02	2.02	1½	0.00	2	0.00	5	+ .15	3	10½	1.50	+ .05	2.30	W. J. Hardee	..
Newport News	2.63	6	1:2:5	4.80	— .25	Natural.	.95	.50	2.20	1½	0.00	1½	+ .19	10	0.00	1	10	1.25	+ .08	2.65	T. C. Hatton	E
New York	2.556	6	1:3:6	5.837	— .15	Portland.	2.50	.45	....	1	+ .10	2	0.00	10	0.00	3	8	2.00	+ .07	2.58	Jacob Wund.	....
Oakland, Cal.	....	6	1:3:5	5.50	0.00	"	2.50[6]	1.00	1.00	No.	+ .28	....	....	..	....	....	..	....	....	....	M. K. Miller	F
Omaha, Neb.	2.11	6	1:2:5	5.00	— .03	Natural.	85-75	65-75	1.35[6]	1½	0.00	1½—2	+ .10	5	+ .15	3	10	1.65-1.85	+.02	2.35	A. Rosewater	..
Peoria, Ill.	1.96	6	1:1½:4	4.50	0.00	"	.55	1.00	1.50	1	+ .10	1½	+ .19	5	+ .15	3	10	1.50-1.75	+.02	2.42	H. E. Beasley	..
Philadelphia, Pa.	2.25‖	6	1:3:6	....	0.00	Prt. & N.	....	....	....	1	0.00	2	0.00	5—10	+ .07	2	..	....	....	....†	Wm. B. Brooks	..
Pittsburg, Pa.	2.44	6	1:2:4	....	— .15	Natural.	.70	.65	1.70	1	+ .10	2	0.00[7]	5	+ .15	2	9-10	1.50-1.60	+.04	2.58	G. W. Wilson	..
Providence, R. I.	2.65	6	1:2:6	5.10	— .29	Portland.	2.20	50-75	2.00	1½	0.00	1½	+ .19	5	+ .15	1	10	1.50-1.75	+.05	2.75	O. F. Clapp	....
Rochester, N. Y.	2.11	6	1:2:4	4.00	— .05	Natural.	.70	1.00	1.10	1	+ .10	2	0.00	10	0.00	3	8	1.50	0.00	2.16	E. A. Fisher	G
San Antonio, Tex	1.995	6	1:2:4	4.40	— .18	"	1.50	1.00	.75	No.	+ .28	2	0.00	10	0.00	1	8	1.50	0.00	2.10	E. G. Truhart	H
San Francisco	1.89	6	1:2½:7	4 86[3]	— .25	Portland.	2.75-$3	.70	1.25[7]	No.	+ .28	2½	— .19	No.	+ .18	5	9	2.00	—.03	1.88	E. G. Morser	I
Scranton, Pa.	2.20	6	1:3:7	4.20	— .17	"	1.80-$2	1.00	1.25	1¼	0.00	1½	+ .19	10	0.00	1	10	1.50	+ .05	2.27	Jos. T. Phillips	K
Spokane, Wash.	2.29	4	1:3:6	7.65	— .30	"	4.50	.70	95—$1	1½	0.00	2	0 00	10	0.00	1	8	1.60-2.00	—.03	1.96	Otto A. Welle	..
St. Paul, Minn.	2.55	6	1:2:4	3.00	0.00	Natural.	....	....	..	1	+ .10	2	0.00	10	0.00	2	10	1.50-1.75	...	2.65	O. Clausen.	..
Syracuse, N. Y.	2.22	6—8	1:2:5[3]	....	0.00	"	....	....	....	....	....	....	....	5	+ .15	2	..	....	....	....†	R. R. Stuart	M
Toledo, O.	1.965	6	1:2:5	....	0.00	"	....	....	....	1	+ .10	2	0.00	5	+ .15	3	10	1.50	+ .05	2.26	Wm. F. Brown	..
Toronto, Ont.	2.75	6	1:3:6	5.40[8]	— .24	Portland.	2.24	.70	1.60	¾	+ .14	2½	— .19	10	0.00	2	9	1.62	0.00	2.46	C. L. Fellowes	N
Utica, N. Y.	2.35	5	1:2:5	4 00	+ .07	Natural.	.85	70—$1	1.25	1	+ .10	2	0.00	10	0.00	3	8	1.50	0.00	2.52	P. L. Schultze	..
Washington, D.C.	1.79	6	1:2:5	3.50	— .07	"	.70	.40	1.25	1½	0.00	1½	+ .19	5	+ .15	2	8	1.20	+ .05	2.11	C. B. Hunt	O
Winnipeg, Man.	1.79	4½	1:3:6	5.74	— .20	Portland.	3.65[3]	1.00	1.10	1½	0.00	1½—2	+ .09	..	+ .18	...‡	9	1.53-1.80	.60	1.76	H. N. Ruttan	..
Average	$2.29	...	.....	....	...	.....	...	...	...	..	...	...	...	..	...	...	..	....	...	$2.41		..

*According to Buffalo specifications. The price given in last column of table is obtained by reducing specifications and prices from respective cities to Buffalo specifications and prices; assuming cost of guarantee for first 5 years is 3 cts. per yard, and the second 5 years is 15 cts. per yard, the total would be 18 cts. per yard. †These are omitted from average of deduced prices in last column of figures on account of insufficient data. ‡Work done by city. §$1.75—$1.43. ‖2.25 to $2.50. [1]$4.86 to $5.50. [2]1:2:5 and 1:3:6. [3]$5.40 to $6.00. [4]Cushion. [5]$2.50 to $3.25. [6]$1.35 to $1.45. [7]$1.25 to $1.50. [8]$3.65 to $3.80. Note A—Price including grading, curbing, etc., $2.91—$2.50; B—No straight work; C—Price including grading, $2.00; D—Rock asphalt; E—Price including grading $2.83; F—California bituminous rock asphalt; G—Price including grading $2.26; H—Bituminous rock asphalt; I—80 miles of bituminous rock pavements; K—Price including grading $2.85; M—Have used Portland cement; N—$2.30 for 2-in. surface on 4-in. concrete; $2.75 for 2½-in. surface on 6-in. concrete; O—Price given for sand and stone does not include haul.

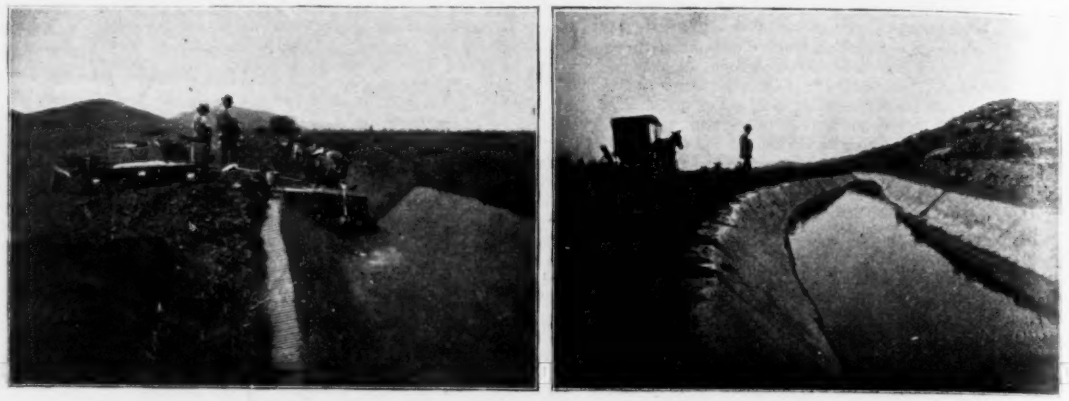
METHOD OF CEMENTING THE IRRIGATION CANALS OF THE NORTH RIVERSIDE & JARUPA CANAL CO.

By E. Duryee.*

The accompanying cut illustrates the method adopted in plastering with cement the canals of the North Riverside & Jarupa Canal Co. The lands irrigated lie in the old Jarupa ranch and extend from West Riverside to Chino in Riverside County, California. They embrace perhaps 8,000 acres adapted to the cultivation of citrus fruit. Without water for irrigation such lands have a speculative value of about $25 per acre, but when water is brought to them their value at once rises from $150 to $200 an acre. Last year much of this land was not under irrigation, and some of the old ditches were not cemented. The water is carried in canals from the San Bernardino artesian belt about ten miles distant, so that the loss by seepage was considerable. Thus while the demand for water was on the increase, the supply on account of this loss and because of the decreased flow of the artesian wells was very scant. Extensive improvements were determined upon; the old ditches were cleaned and plastered and new ones opened so that the system now embraces 14 miles of cemented ditches of various dimensions.

In preparing for the cementing work, sand is first hauled from nearby river beds, or washes as they are called, and dumped alone the line of the ditch where it will be required for mortar. Cement is hauled by six-horse teams from the works of the California Portland Cement Co., about ten miles distant. The laborers are boarded in temporary tent camps in order to be near the work as it advances. With the exception of a foreman and two trowelers ordinary day laborers are employed. A mortar-bed on wheels is drawn by a horse along the edge of the canal, keeping pace with the plasterers. Shovelers in advance of the plasterers clean out and even off the surface, and a man with a hose follows and sprinkles the surface so that it is thoroughly wet before plastering.

The sand is not screened, but is selected to contain a good proportion of coarse as well as fine grains and to be clean. It is mixed on the portable bed in the proportions of one of cement to four of sand. It is mixed with hoes, first dry then wet. The mortar is then slid down the chute onto a bed from which the shovellers spread it along the bottom and sides as fast as the trowelers can spread it to a surface. This coat of plaster is generally made from ¼ to ½-in. thick on canal work, but on this work the coat was from ⅛ to ¼-in. thick. Within fifteen minutes after water has been added to the mortar the last of it is plastered on the ditch. The plastered surface is sometimes washed over with a wash of pure cement and water applied with a brush to make it more impervious to water. After standing a couple of days, water is allowed in the finished section, but is kept stagnant by means of temporary dirt dams. From these reservoirs temporary lines of ¾-in. iron pipes carry water to the mortar bed as it keeps pace with the construction.



VIEWS SHOWING METHOD OF CEMENTING THE IRRIGATION CANALS OF THE NORTH RIVERSIDE & JARUPA CANAL CO., CALIFORNIA.

*Colton, Cal.

THE TRACK ELEVATION OF CHICAGO will have an important extension under two ordinances which after long opposition and frequent amendments have been passed by the city council and accepted by the railway companies concerned. The first of these is for elevating the parallel tracks of the Chicago & Northwestern Ry., Chicago, Milwaukee & St. Paul Ry., and Pittsburg, Cincinnati, Chicago & St. Louis Ry. along Kinzie St., from Ada St. west to the points where the elevation of the several roads now commences. This will bring the track elevation almost to the river. The other ordinance is for the extension of the elevation of the parallel tracks of the Lake Shore & Michigan Southern Ry., and Chicago, Rock Island & Pacific Ry., from 16th St., north to the terminal station or Van Buren St. In connection with this work, a new station will be built, with direct connection between the tracks of the terminal station and the adjacent station of the elevated railway. These two pieces of track elevation will remove some very long and dangerous grade crossings in busy sections of the city. The next important piece of track elevation to be taken up will be at Grand Crossing, which is a very complicated crossing of three separate roads. The Pittsburg, Chicago & Fort Wayne Ry. will probably be depressed and the Lake Shore & Michigan Southern Ry. elevated, while the Illinois Central R. R. will be elevated about 35 ft., so as to pass over both the other roads.

ANNUAL MEETING OF THE INDIANA ENGINEERING SOCIETY.

The 21st annual meeting of this society was held at Indianapolis, Ind., Feb. 14, 15 and 16, the headquarters and place of meeting being at the English Hotel. At the opening meeting in the afternoon of Feb. 14 the President, Mr. J. S. Spiker (of Vincennes), read the annual address, in which he referred to the importance of promoting the interests and development of the society. This address was quite extensively discussed, and one point brought up was the connection between engineers and local politics. Mr. H. B. Fatout (of Indianapolis) considered that the engineer, while taking an interest in politics, should in no way be a politician. Mr. Tratman, of the editorial staff of Engineering News, being called on, suggested the importance of keeping committees and members who have promised papers reminded as to their duties, so that the program may not be disturbed by the failure of committees to present reports or of members to present papers. He also expressed surprise that no excursions had been arranged, as these tend to promote sociability, and a city like Indianapolis certainly has ample points of interest for an afternoon's excursion.

Neither of the standing committees on the program had reports to present, and this led to some discussion as to committees and their work, in the course of which it was shown that the constitution provides for several committees to which members have not been appointed. The society is in need of some vigorous action by its officers and its members to put it on a better working basis. Its business has been somewhat neglected of late, owing to the long continued serious illness of the secretary, Mr. W. Cleary. Mr. F. W. Keller (South Bend) was elected Secretary pro tem.

At the morning session on Feb. 15 the report of the Secretary was presented and Mr. H. B. Fatout presented the report of the Committee on Questions of Practice. This committee was first started to consider the difficult problems encountered by surveyors from time to time, but no such problems had been submitted during the past year, and the report dealt mainly with the general troubles due to mistakes in measurements or readings, and to the employment of inexperienced help. Several cases were cited which had occurred in Mr. Fatout's long experience as a county surveyor. The report brought out some general discussion. A paper was then read by Mr. John Finan, Jr., City Engineer of Elwood, Ind., an abstract of which is given below:

STREET PAVING IN ELWOOD, IND.

As macadam had been tried and found unsatisfactory for streets with heavy traffic, the city in 1891 adopted the old Canton brick on a foundation of broken stone and gravel, about 10 ins. thick. The pavement was rolled and a pitch filler used. This paving, laid in 1891, is still in good condition and has cost nothing for repair, although subjected to very heavy traffic. Since that time nothing but brick paving has been laid. Asphalt paving is more expensive to lay and to maintain, and wooden block paving is not approved. Streets paved with common brick 8 years ago and all the streets paved with vitrified brick are in good condition, except where they have been torn up for trenching.

To prevent this trouble the gas mains are being moved to the alleys and the water company is required to lay house connections to the curb line in advance of street improvements. Sewer connections are built in the same way. Under these conditions cement or Murphy's filler may be used for grouting, the former being preferable. Where the paving is likely to be torn up, however, a filling of fine sand may be used.

The sub-grade should be carefully prepared, soft places excavated and refilled with gravel and the surface well rolled. About 10 ins. of gravel should then be deposited and dressed off with a template, but not rolled, and not traveled over more than is necessary to handle the material. I have long ago abandoned the idea that gravel should be rolled before the bricks are laid.

For rolling the pavement some engineers think the roller should weigh 15 or 20 tons. The best results I have obtained have been by rolling three or four times with a 3-ton roller and finishing with a 6-ton horse roller when the pavement has been fully settled.

A paper on "The Mississippi River Commission Surveys," by Prof. C. V. Seastone (Purdue University) was then read by the Secretary, and Prof. R. L. Sackett (Purdue University) read a short paper on "Railroading in Great Britain," giving some observations made during a recent trip. Mr. A. J. Hammond (Asst. Engr., Vandalia R. R.) then read a paper, some extracts from which are given below.

STREAM POLLUTION.

About 12 years ago the American Public Health Association's committee on the pollution of water supply concluded its report with a resolution to the effect that state legislatures should give their boards of health financial support and also invest them with the supervision of the water supplies and power to preserve the waters from contamination. Prior to that time only Massachusetts, New York and Minnesota had to any large degree turned over to these boards the sanitary protection of their surface waters. The laws in Massachusetts have been broadened during the last decade, and this state is now a model in this respect.

A number of other states have granted increased powers to their boards of health. In 1899 North Carolina provided additional laws, requiring a quarterly inspection of drainage areas from which water supplies are drawn, these to be made at the expense of the owner, whether corporation or municipality. The pollution of any source of water supply was made a misdemeanor, punishable by $1,000 fine or one year's imprisonment as a maximum.

I understand that there is a bill now before the Indiana legislature which prohibits the discharge of waste water and refuse matter into running streams, except on a permit issued by the State Board of Health. I do not believe such a permit would be worth the paper it was written on if the board is not provided with the necessary funds to make exhaustive tests as to the probable pollution caused by such wastes, and given the authority to carry on continuous observations, inspections and tests which would be required to determine such pollution.

In 1897 some 50 cities in Indiana were reported to be using surface water, but within the past few years a number have been compelled by the pollution of this water to resort to filtration or to restrict its use to fire protection purposes. This pollution has been caused principally by the waste products of mills, factories and mines.

The paper gave a number of cases of litigation in regard to pollution of water (quoting largely from an editorial in Engineering News, Nov. 9, 1899), and also discussed the condition of the several rivers of the state. It concluded by a recommendation that the society should lend its aid to the Board of Health, and as a result of this a resolution was adopted to the effect that a committee should be appointed to consider the bills relating to public health which are now before the legislature.

At the afternoon session Mr. V. K. Hendricks (Engr. Maint. of Way, Terre Haute & Logansport R. R.) read a paper on "Concrete Construction as a Substitute for Brick and Stone Masonry," in which were given detailed specifications for concrete work. Prof. S. B. Newberry then read a paper on "Manufacture of Portland Cement in America," in which he showed the enormous growth of this industry and the high degree of perfection which has been attained in cement machinery and the cement product. While it is very generally considered that German Portland cements are the best, he showed that the best imported cements are much coarser and of less strength than the best American cements. He strongly approved of the boiling test as a reliable test of the durability of cement, although this test is not recognized in Germany. An interesting paper was then read by Prof. W. D. Pence (Purdue University).

THE DESIGN AND CONSTRUCTION OF MASONRY ARCHES.

Two general types of so-called permanent bridge or bridge-deck construction are in more or less general use: (1) The masonry arch proper; (2) the concrete-steel construction. The principal forms of the latter are as follows: (A) the Melan arch, with curved I-beams embedded

in the concrete arch; this has its most favorable application in long span arches, especially in highway and park bridges. (B) The Monier construction, in which expanded metal or steel netting is used to reinforce the concrete; this is now having a wide application in other fields than bridge construction. (C) Buckle plate construction, in which the concrete is supported by arched steel plates resting on the flanges of metal beams; this has been used for a number of city bridges, and while the corrosion of the plates is often quite rapid, it is usually assumed that the concrete will be self-supporting. (D) Concrete-steel beam construction; in this case straight steel beams are encased in a concrete sheet or mass, and this system has been used in a number of false-arched road bridges. Although water may percolate through good concrete to a certain extent, experience shows that well-painted metal hermetically sealed in a mass of concrete is free from deterioration, even though it be located below the level of constant saturation.

In the ideal masonry arch, the line of pressure for permanent or dead loading coincides with the center line of the arch ring, and the line as modified by the moving or live load does not depart from the middle third. This ideal condition may be approximated if the roadway is supported on spandrel arches (as in important foreign bridges), so that the loading is transmitted to the arch ring in definite vertical lines. In this country, however, the cheaper plan of filling the spandrels with earth is commonly used, and much uncertainty attends the determination of the horizontal pressure to be allowed for in analyzing the arch.

The dimensioning of the arch ring is essentially a cut-and-dry process. Having fixed the span, rise and curvature of the arch ring, its thickness at the crown is assumed, the loading computed and the line of pressure located. If the line falls within the middle third, the dimensions assumed may be approved, or even reduced. If there is difficulty in keeping the line within the middle third, a greater crown depth may be assumed, or the depth may be increased from the crown to the springing lines. We should consider the design with reference to the three methods of failure to which an arch ring is subject: (1) By rotation; (2) by crushing; (3) by the sliding of one voussoir on another.

In assuming the trial dimensions of the arch ring one may be governed by the corresponding dimensions of other similar structures, or an empirical formula may be used as a guide. Various formulas have been proposed in foreign countries, and in this country Trautwine's rules for dimensioning the keystone and abutments of stone bridges have guided the practice of a large number of engineers for 30 years.

Unless the engineer is sure that he is able to follow correct methods in ornamentation, he had better construct a plain piece of masonry. There is always dignity in a well balanced and well constructed masonry structure, which may be lost by even a little faulty embellishment.

Plans and photographs of a stone arch bridge designed by Prof. Pence and built under his direction were exhibited. The last paper of the afternoon was on "The Strength of American Slag Cements," by Prof. W. K. Hatt (Purdue University), and an abstract of this we shall give in another issue.

On Saturday, Feb. 16, the meeting was called to order about 9.30 a. m., and the Secretary read a paper by Mr. R. L. Bailey on "Relations of the Engineer and the Contractor." Mr. John W. Fulwider then read a paper on "The Conditions of Engineering Work in Lebanon, Ind.," describing the municipal engineering works of that city. The last paper on the program was "Sewage Disposal and Refuse Destruction," by Mr. F. Herbert Snow (Boston, Mass.), and this was read by Mr. C. C. Brown, in the absence of the author.

On recommendation of the committee appointed the previous day, a resolution was adopted in favor of a bill now before the legislature, to protect the streams and water supplies from pollution, establishing a state laboratory and giving the Board of Health jurisdiction over cases in which mill waste or other refuse is discharged into the streams. As some local newspapers had been accusing the society of lobbying in favor of certain bills for the benefit of its members, a resolution was adopted, on motion of Mr. C. G. H. Goss, to the effect that such assertions are entirely untruthful and unwarranted, the society having no interest in any personal matters.

The election of officers resulted as follows: President, Prof. Wm. D. Pence (Purdue University), Lafayette, Ind.; Vice-President, Prof. R. L. Sackett (Purdue University), Lafayette, Ind.; Secretary, C. C. Brown, Indianapolis, Ind.

The meeting was an unusually successful one, in spite of the unfavorable conditions due to the long illness of the former secretary. The society has now about 75 members, including those elected at the meeting, and about 30 members were present.

REMOVAL OF IRON FROM THE WATER SUPPLY OF SUPERIOR, WIS.

By R. D. Chase, Assoc. M. Am. Soc. C. E.*

The city of Superior is located at the head of Lake Superior, on Superior Bay. Although there has been a settlement there since the '50's, the real beginning of the city was in 1887-8. It had a population of 31,091, by the census of 1900. In 1888 a franchise for furnishing water to the city was given to a corporation, now merged into the Superior Water, Light & Power Co.

HISTORICAL.—There have been since 1888 various sources of water supply. The first was from a slip, Fig. 1, on the bay front, a small pump on the dock furnishing direct pressure to a portion of West Superior. The next station was located a mile to the south, where the gas and electric plants were. The water was taken from a crib in the bay, a short distance from the shore. The water was highly colored, and was run through mechanical pressure filters, alum being used as a coagulant. The next water supply was taken from Lake Superior in 1891. The present pumping station was built two miles south of the second station, on the bay front, at "Old Town," Fig. 1. From this station a 24-in. cast-iron pipe, 7,000 ft. long, was laid across the bay and out into the lake, the end being in 26 ft. of water. This water was at times very turbid, and gave rise to much complaint. This supply was, however, retained until 1896, when a filter gallery was built on Minnesota Point, connecting directly with the suction main. This gallery was not successful, a very objectionable growth of algae forming in it.

The next supply was from a set of driven wells on the lake shore of Minnesota Point, Fig. 1. These wells, 80 in number, are from 40 to 60 ft. deep, with the lower 20 ft. formed of a Cook strainer. This water, as it came from the wells, was very satisfactory in appearance, but contained iron in solution as the carbonate. This carbonate on standing deposited as the oxide, and besides supported a growth of crenothrix in the suction and street mains, which washed off on any increase in velocity, and gave the water a very pronounced red color.

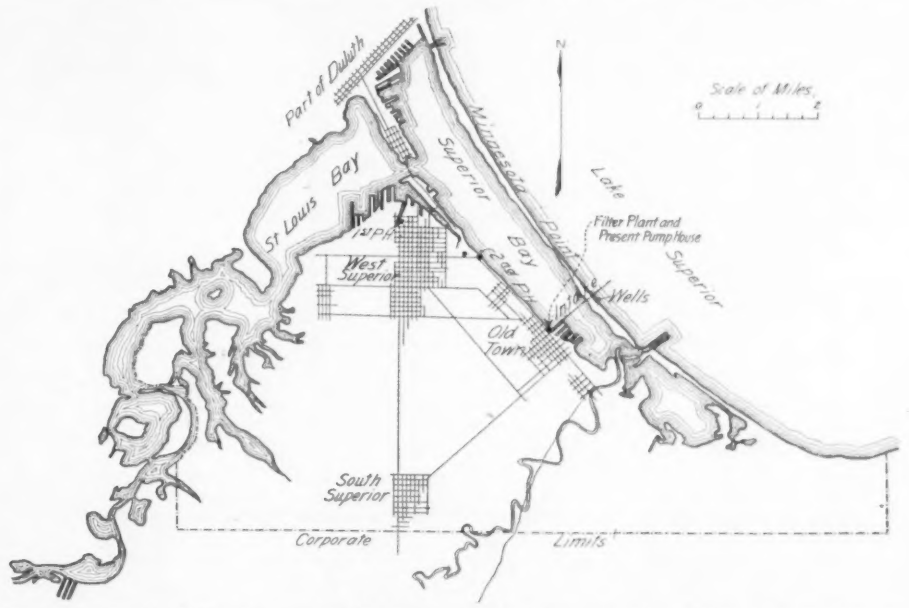


FIG. 1.—GENERAL MAP OF SUPERIOR, WIS., SHOWING LOCATION OF WELLS, PUMPING STATION AND FILTER BEDS.

On account of these various failures to furnish a good supply the water company had been in legal difficulties with the city for a number of years. To end the matter the company determined to make a radical change.

The situation in Superior is in some respects difficult. The water in the bay directly in front of the city receives the sewage of Superior, and a part of Duluth; but, aside from this, the water is largely from the St. Louis River, a stream having a drainage area of over 3,000 sq. miles, and emptying into the bay. The lake water rarely enters the bay, and the water in the bay is thus the St. Louis River water, colored with peaty matter to a most unusual extent, and carrying in addition finely divided iron ore, clay and other turbidity, in such an amount as to make its use for water supply utterly impossible.

A dozen miles back of the city the ground rises to such an elevation that one of the rivers or small ponds could be taken for a gravity supply. Unfortunately this water also carries peaty matter to a most unusual extent, and the volume of the streams, too, is said to be unreliable, the water being, in large measure, carried off by underground channels in long continued droughts.

The lake beyond Minnesota Point (see the map, Fig. 1) is much less objectionable than the bay water, but there are many times, particularly when the St. Louis River is in flood, when the river water forms a large proportion of the mixture which could be reached at any point where the intake could be placed. Duluth has avoided this condition by going 12 miles down the north shore; but owing to the currents and the natural topography of the position, it is hardly possible for Superior to get a corresponding water from the south shore.

The wells on Minnesota Point furnished a ground water abundant in quantity, and seemed to offer a most satisfactory solution of the problem. If it had not been for the iron contained in the water this would have been the case. As it was, the iron supported growths of crenothrix in the pipes, which were flushed out from time to time, with the usual objectionable results; but in this case the popular prejudice was excited by an entirely accidental circumstance. The crenothrix made the water red. The water in the bay was red from iron ore and red clay. When the red water was drawn from the taps the people at once jumped to the conclusion that it was bay water and not well water which they were receiving. This popular prejudice was too strong to be shaken by any statements which could be made, and the city employed Mr. Floyd Davis, of Des Moines, Iowa, to investigate the situation. Mr. Davis found that the intake pipe under the bay leaked somewhat, and that a certain amount of bay water was mixed with the well water. This finding being announced, the prejudice was greatly increased and strengthened, notwithstanding the fact that it was subsequently demonstrated that the proportion of bay water in the pipe did not exceed about 1%, which amount was too small to affect noticeably the appearance of the water.

The company at this time, that is, in the summer of 1898, employed Prof. E. G. Smith, of Beloit, Wis., as chemist, and Prof. H. L. Russell, of Madison, Wis., as bacteriologist, to make exhaustive examinations of its supply, and to make studies looking toward its improvement. Mr. R. S. Weston, of Boston, as Professor Smith's representative, took charge of the actual operations in the field, and Mr. Allen Hazen, M. Am. Soc. C. E., of New York, was also employed to advise with reference to the experiments, and more particularly to devise means for carrying out whatever general project seemed most promising.

It was found by experiments, which were made by Mr. Weston, that the impurities of the bay water were of such a character that even when treated with four grains per gallon of sulphate of alumina they were not properly coagulated, and could not be removed with mechanical filters, and the chemical composition of the water was such as not to allow a larger quantity to be used, even

*220 Broadway, New York city.

though it had been otherwise desirable. The lake water could probably have been treated, although at a heavy expense for coagulant, but no prolonged experiments were made with it. It was found that the well water could be freed from iron by proper treatment, namely, by aeration, followed by filtration; although either because of the carbonic acid which it contained, or because of small amounts of peaty matter, the oxidation and separation of the iron were much less rapid than had been found in other cases. In experimenting with a mechanical filter, separation of the iron was hastened by the addition of chemicals, but even when this was done the removal of iron was never complete; and further, the effluent from the mechanical filter had the property of rapidly attacking iron surfaces with which it came in contact, so that even though it were satisfactory as delivered, there was a question as to whether it could be supplied in good condition through iron pipes.

An experimental sand filter, operating at a rate of 5,000,000 to 10,000,000 gallons per acre daily, gave an effluent containing generally less iron than the effluent from the mechanical filter, and ordinary consumption. The plant was operated on the direct pressure system. The maximum capacity of the pumps was about 4,500,000 gallons. As the fire consumption at times equalled this amount, and as there was no possibility of building a storage reservoir, the filtration plant had to be built to provide for the maximum consumption. This was taken at 5,000,000 gallons per day, and the pipe connections and pump were designed for this quantity. This corresponds to a rate of 10,000,000 gallons per acre daily with three filters (as built), or 15,000,000 gallons per acre daily with two filters in use. This is a very high rate for a sand filtration plant, but in this case the only thing to remove from the water is the precipitated iron and the crenothrix, which are both large and flocculent. The water as it comes from the wells contains very few bacteria, which analysis shows to be non-pathogenic, consequently there is no need of keeping the rate as low as is necessary in the case of sewage contamination.

The well water carries the iron in solution as the carbonate, and as the well water contains no oxygen, and it must be the lake water originally, voir, shown in plan and section by Fig. 2, with an aerator and gate house, all located on the bluff, about 30 ft. above and 300 ft. northwest of the pumping station. An addition to the pumping station was also built, containing a new 5,000,000-gallon pump.

PUMP.—The old pumps were directly connected to the suction main and to the city mains. To get the water from the wells to the filter required a low lift pump, the water flowing by gravity from the filters to the direct pressure pumps. The new pump is a Worthington, triple expansion, duplex, with surface condenser. The steam cylinders are 9, 14 and 22 ins. in diameter, and the water cylinders are 18½ ins. in diameter, all with an 18-in. stroke. The pump was guaranteed for a duty of 80,000,000 ft.-lbs. per 1,000 lbs. of steam.

A duty test was made on the pump, lasting for ten hours. The piping was so arranged that all the steam used went in through the condenser and was weighed. Three measurements of the water pumped were made by turning all of the water into one filter and computing the quantity from the rise in level, the exact area being known.

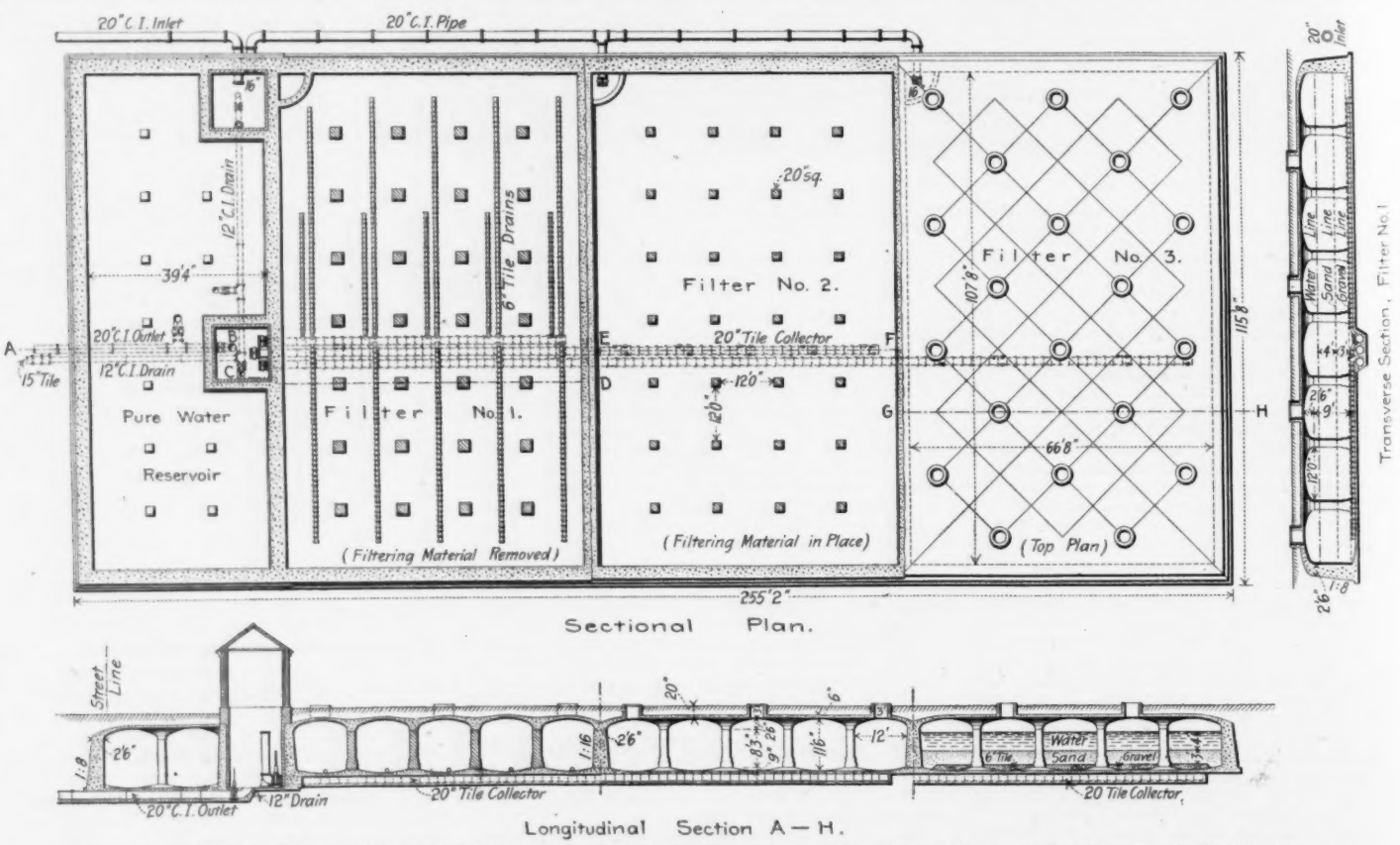


FIG. 2.—GENERAL PLAN AND SECTIONS OF COVERED FILTER BEDS AND CLEAR WATER RESERVOIR, SUPERIOR, WIS.
Allen Hazen, M. Am. Soc. C. E., Consulting Engineer; R. D. Chase, Assoc. M. Am. Soc. C. E., Resident Engineer.

on a few occasions, when more vigorous aeration was applied, the removal of iron was almost complete. It appeared probable from these experiments that the water could be satisfactorily purified by either sand or mechanical filters. Although the results from the mechanical filters had been less favorable, bids for mechanical filters were first invited and the filter companies were requested to guarantee the results. The bids obtained were not regarded as satisfactory, and the water company decided to construct sand filters. Plans were prepared, submitted to the city authorities and approved, and shortly afterward the work of construction was commenced, in July, 1899.

GENERAL DESCRIPTION.—In 1899 the company was pumping about 2,500,000 gallons of water per day. Of this amount nearly 1,000,000 gallons was used in flushing mains. The method used was to open a hydrant to a limited extent, care being taken not to reduce materially the pressure. This served only to remove the dirty water, but had no effect in scouring the pipe. This left 1,500,000 gallons per day as the which has oxygen, the change probably takes place somewhat as follows: The lake water containing oxygen, in passing through the sand comes in contact with peaty matter which is oxidized, using up all the oxygen, and forming carbonic acid gas. In the sand are considerable quantities of iron occurring as the oxide. The water containing the carbonic acid gas in solution dissolves the iron oxide, forming the carbonate. While in solution in the mains this supports a growth of crenothrix, and when allowed to stand in contact with the atmosphere the iron deposits as the hydrate. Both of these changes are very objectionable. The plant was designed to bring about the second of these actions before the water enters the mains, and to filter out the precipitated iron. To do this, the water is aerated by a device to be described later, which aeration removes part of the carbonic acid gas and thoroughly saturates the water with oxygen, thus precipitating the iron, which is taken out by the filters.

The plant as designed and built comprised three concrete covered filters and a pure water reser- From this the quantity of water pumped per stroke was figured. By plunger displacement the number of gallons per stroke was 84.6. The average of the three experiments showed 80.9 gallons pumped per stroke, or a slip of 4.4%. On this basis (80.9 gallons) the pump showed a duty of 87,000,000 ft.-lbs. per 1,000 lbs. of steam.

AERATOR.—After leaving the pump the water passes through the aerator, Fig. 3. This rests upon an open masonry chamber, 12 × 12 ft., built in one corner of the pure water reservoir. The aerator consists of two tiers of four trays each, spaced about 2 ft. apart, vertically. The bottom of these trays is a steel plate ¼-in. thick, punched with 3,900 ¼-in. holes. The water coming from the pump discharges into a trough above these trays and from the trough in either direction into the upper of the two sets of trays. The water in falling through these four trays gets a very thorough aeration. From the lower tray the water falls into the masonry chamber and from there goes to the filters.

FILTERS.—The three filters, Fig. 2, are each 107.67 × 66.67 ft., and the pure water reservoir is

107.67 × 39.33 ft., the whole occupying a lot 120 × 255 ft. The whole work was of Portland cement concrete, except the piers, and the lining to the aerator and gate chamber, which are of brick laid in Portland cement.

The floor is a series of inverted groined arches. This form was selected to distribute the load of the piers uniformly over the whole area. The excavation was entirely in a red clay, which made a good bottom, but was very expensive to handle. The floor was laid in squares, following the diagonal lines of the intersections of the groins. This seems to be the best way to get the pier foundations well tamped. The surface was made smooth by screeding and was then troweled to fill all small holes and to make the surface water tight.

The exterior walls are vertical on the inside and have a batter of 1 on 8 on the outside. The interior or division walls have a batter of 1 on 16 on each side. Wooden forms were built, corresponding to the section desired, and filled with concrete. After the concrete had set the forms were torn down and the lumber used again.

The piers are of brick, 20 ins. square, with two offsets at the bottom to avoid a vertical joint through the sand and thereby allow improperly filtered water to get to the underdrains.

The roof is formed of elliptical groined arches, as shown by Figs. 2, 4 and 5, with a span of 12 ft. and a rise of 2½ ft. The thickness of concrete at the crown of the arch is 6 ins., and over the piers it is kept 6 ins. low, and the hollow thus formed drained through a 2-in. tile in the center of the pier, discharging just above the sand line. The roof centering was built in sections outside the filters and when the walls and piers of the first filter were completed was set up in it. The centering was supported on wedges, and the whole was made so that it could be easily taken down when the concrete had set and be assembled in the next filter. Generally a few slight repairs to the lagging were all that was necessary to be done to make the forms again serviceable.

Manholes, 3 ft. in diameter and 8 ins. thick, provided with double covers of steel plate, were placed in alternate arches, their tops projecting 6 ins. above the finished fill.

The filters are covered with 2 ft. of dirt, the excavated clay being used for this purpose. As a precaution against the severe frosts, the top of the concrete was first covered with an inch or two of sand. This also improved the drainage of the top of the filters.

The pure water reservoir, Figs. 2 and 4, is similar in construction to the filters. The bottom is 3 ft. below the filter floor. Taken out of the area of the pure water reservoir are two chambers, each 12 ft. square, one for the gate chamber, the other for the aerator. The capacity of the reservoir is 300,000 gallons when full. Besides furnishing a small storage, the reservoir prevents the rapid fluctuations of rate of filtration which would otherwise occur as the speed of the pump varied.

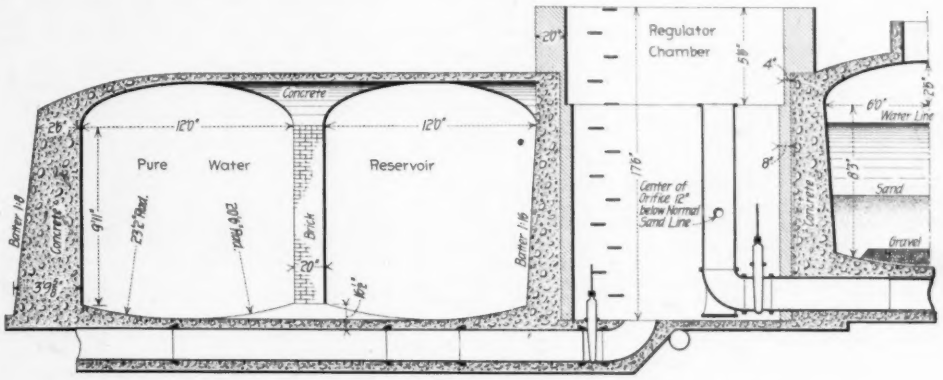
The inlets to the filters are 16-in. pipes, controlled by standard valves. The water is taken from the aerator chamber to the adjacent filter by a short pipe through the wall, and to the two further filters by a 20-in. pipe, reducing to a 16-in. The inlet valves are provided with an extension stem and indicator post on top of the filters. Around the inlet valve a circular wall is built to the sand line to prevent the sand from being washed away by the water.

On top of the gravel was placed 3 ft. of sand. This was obtained for two of the filters from Superior Entry in about 26 ft. of water. For the third filter, the sand was carted over from Minnesota Point, after the ice had formed. The Entry sand had an effective size of about 0.28 mm. and the Point sand of about 0.32 mm.

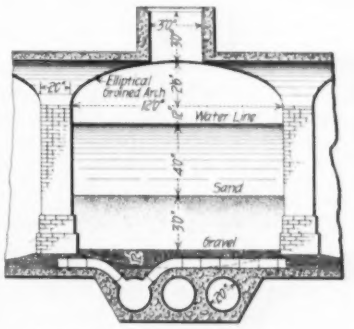
Under normal conditions 4 ft. of water is to be carried on top of the sand. This level is controlled by an overflow in the aerator chamber, which is always open and discharges into a drain leading to the bay.

As a means of measuring approximately the quantity of water delivered by each filter, the main drains are terminated inside the gate house by vertical pipes, in which are four 6-in. orifices, 1 ft. below the sand line, as shown in Fig. 4. Below the orifices are valves fitted with extension stems and hand wheels for controlling the rate of each filter. The gate house also contains valves and connections to drain the filters separately into the sewer; also a valve and connection to drain the gate house, and a valve on the 20-in. supply to the pumps on the city mains.

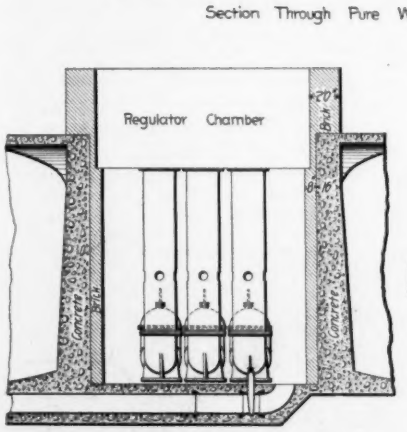
The pure water reservoir is connected to the gate chamber by a branch on the 20-in. supply to the pumps, controlled by a valve so that either the gate chamber or the reservoir can be cut out and cleaned.

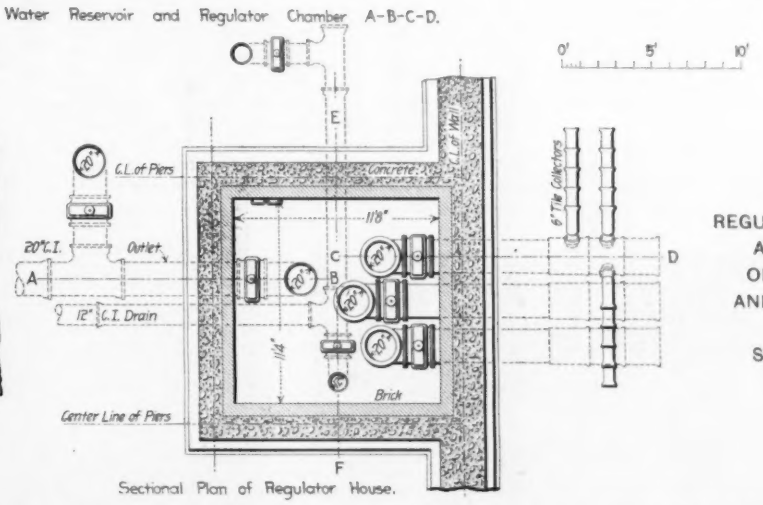


Section Through Pure Water Reservoir and Regulator Chamber A-B-C-D.



Section Through Center of Arches Showing Tile Drains and Main Collectors.





Sectional Plan of Regulator House.

FIG. 4.
DETAILS OF REGULATING CHAMBER AND SECTIONS OF FILTER BED AND CLEAR WATER RESERVOIR, SUPERIOR, WIS.

The main underdrains are placed entirely below the floor of the filter. They are tile pipe, 20 ins. in diameter, and are provided with fifteen 6-in. connections, extending above the floor. The shape of the lot occupied made it necessary to carry the underdrains of the farthest filters below the floor of the other filters. On top of the concrete floor are laid 6-in. tile underdrains with open joints, connecting with the openings in the main drain. As the main drains were not in the middle of the filters, the 6-in. tile drain was doubled on the long side for a portion of the way.

The filter gravel was placed in three layers of different sizes, the coarsest at the bottom. The coarse gravel surrounding the underdrains was not less than 1 in. thick nor more than 3 ins. in its longest dimension. Over this and leveling up the groins to a maximum depth of 10 ins. was the second layer. This was composed of a gravel which was refused by a ⅜-in. mesh and which would all pass a 1-in. mesh. On top of this was placed 2 ins. of gravel, which passed a ⅜-in. mesh. In two filters this was covered by ½-in. of coarse sand, which was obtained from the tailings of the filter sand.

PUMPING STATION.—It was originally planned to place the new pump in the old pumping station, with the suction at the same elevation as the intake main, which was 5 ft. below the lake level. This would make the foundation of the new pump about 10 ft. below the foundation of the other pumps. It was desired to place the pump as low as the intake because in this way water could be taken from the wells at a lower level, and with the uncommonly long suction pipe this is an important matter.

The old building and pump rested upon hardpan, but there had been much trouble from settlement. A test pit showed that the hardpan extended only 1 ft. below the foundations of the old pump, and that underneath this were pockets of quicksand. In the bottom of the test pit a pipe was jetted 50 ft. below the lake level without finding any hard bottom. To put the new pump in the old building would have necessitated digging a pit 10 ft. below the old pump foundation

and close to it, and as the walls of the station had settled and cracked badly before operations were commenced, it was determined to pull down 16 ft. of the old building and rebuild that end 50 ft. long, placing the new structure on piles. The new pump was put near the end of the addition, and in the intervening space were driven piles for another pump, which will be needed in the future.

As any settlement of the old foundations would have been a serious matter, a row of sheet-piling was driven across the station, separating the old and the new parts, in order to prevent the quicksand from flowing from under the old foundations. The piles were jetted in all cases, to reduce the amount of driving necessary and the consequent jar. No settlement of the old work was noticed.

The foundation walls of the station are of concrete to within 2 ft. of the surface, and from that point to the water table are of rubble. As there was very considerable delay in getting the piles driven, it was cold weather before the concreting was begun, and although the sand and water used was heated, the concrete often froze in an hour after it was in the wall. The work was carried on, however, at any temperature above — 20° F., and when it thawed out in the spring no settlement or cracks were observed.

COST.—In June, 1899, bids were invited from a few firms for the construction of the filters. The prices seemed high, and no award was made, but instead, George J. Grant, of St. Paul, was given the work on a percentage basis. From the very beginning there was much difficulty in getting supplies. The work was done at the time prices were at the highest. The cost of some of the material bought in the town was excessive; sand and gravel, for example. The company was required under heavy penalties to finish the work in December, 1899, and it seemed as if advantage were taken of this, for apparently every one had enough to do and would only furnish material at his own price. Labor was hard to get and inefficient at $2 a day. The preliminary estimates of cost, amounting to $63,000, were made in the winter, before prices advanced, and were considerably below the actual cost of the work. The main items were divided approximately, as shown by the accompanying table:

Cost of Iron Removal Plant at West Superior, Wis.

Filters and pure water reservoir:		
Excavation	14,000 cu. yds. at $0.55 +	$7,630
Back fill	2,000 " " " .30 +	600
Concrete	3,000 " " " 7.85 +	23,500
Arch centering		1,910
Brick work	120 cu. yds. at $10.00 +	1,200
Iron pipe and specials, gates, etc.		5,700
Tile pipe		860
Filter gravel in place, 600 cu. yds. at $4.95		2,970
Filter sand	1,000 cu. yds. at $3.04 +	
" "	800 " " " .97 +	4,860
Aerator		470
Miscellaneous charges		2,350
Land, including land for extension of equal capacity of present plant		6,280
Engineering, percentage to contractor and other expenses		9,204
Pump-house extension, pump and connections		21,170
Total		$88,704

The filters were completed in December, 1899, but it was not possible to use them until the completion of the pumping plant in April, 1900.

RESULTS.—The filters were started in April, 1900. Although the water from the filter was clear and contained no ferrous iron, the water as drawn in the city did not improve materially at first. The pipe system of Superior is unusually large in proportion to the quantity of water supplied, and enormous quantities of crenothrix were attached to the pipes, and kept coming off gradually with increase of flow at fires and other disturbances. It was only after some time, and after a much more thorough and systematic flushing of the pipes than had formerly been used, that the water drawn in the city became of substantially the same quality as that pumped into the mains from the filters. Examinations of the aerator showed that the water became thoroughly saturated with oxygen, while fully three-fourths of the free carbonic acid was removed. Notwithstanding this, the oxidation of the iron is much slower than it has been in other cases, and the effluent carried an extremely small quantity of ferric oxide in suspension at first, although entirely free from ferrous iron.

In the filters the iron forms on top of the sand in a thin layer, like felt, which is water-tight, at a thickness of less than ⅛-in. This covering is lifted off with shovels and thrown into piles under the manholes, and then hoisted out in buckets, using a tripod and a pair of horses, as shown by Fig. 6.

The cost of cleaning is about $1.48 per 1,000,000 gallons of water filtered. It will average about as follows:

5 men scraping, 3 hours at 20 cts. an hour	$3.00
1 team hoisting, 2 hours at 40 cts. an hour	.80
5 men hoisting, 2 hours at 20 cts. an hour	2.00
5 men smoothing, 2 hours at 20 cts. an hour	2.00
Total cost of labor	$7.80
Sand to be replaced, estimated at 10 cu. yds. at $1	$10.00
Average quantity filtered by one filter between scrapings, 12,000,000 gallons.	
Cost of labor per 1,000,000 gallons	$0.65
Cost of sand per 1,000,000 gallons	.83
Total cost per million gallons	$1.48

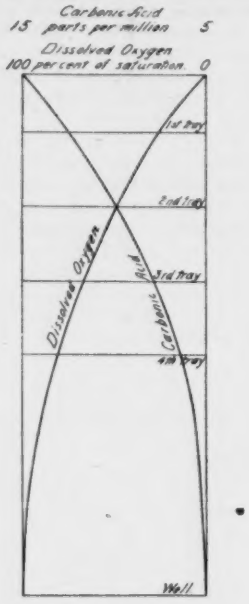


Diagram Showing Absorption of Oxygen and Decrease of Carbonic Acid, June 26, 1900. Temperature of Water, 54° F.

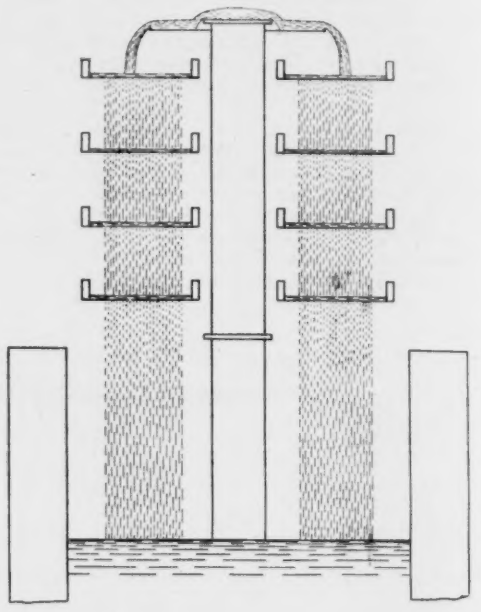


Diagram of Aerator.

FIG. 3.—DIAGRAMS ILLUSTRATING OPERATION OF WATER AERATOR, SUPERIOR, WIS.

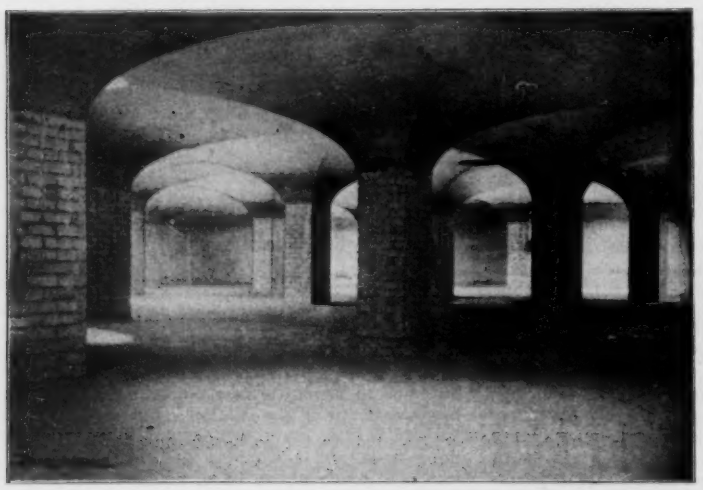


FIG. 5.—VIEW OF CLEAN FILTER BED, SUPERIOR, WIS.

FIG. 6.—HOISTING DIRTY SAND FROM FILTER BED, AT SUPERIOR, WIS.

Mr. Allen Hazen, M. Am. Soc. C. E., New York, acted as engineer for the company throughout. The writer drew the plans under his direction, and acted as resident engineer in the construction of the plant. Much assistance and many valuable suggestions were also received from Major R. B. C. Bement, M. Am. Soc. C. E., Acting General Manager of the company to Jan. 1, 1900; and from Mr. B. F. Ellison, General Manager of the company since that date; and from Mr. Winslow, Secretary of the company.